MODA Example Studies

Lecture 51, v01

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BSEE

MSSE

INCOSE ESEP

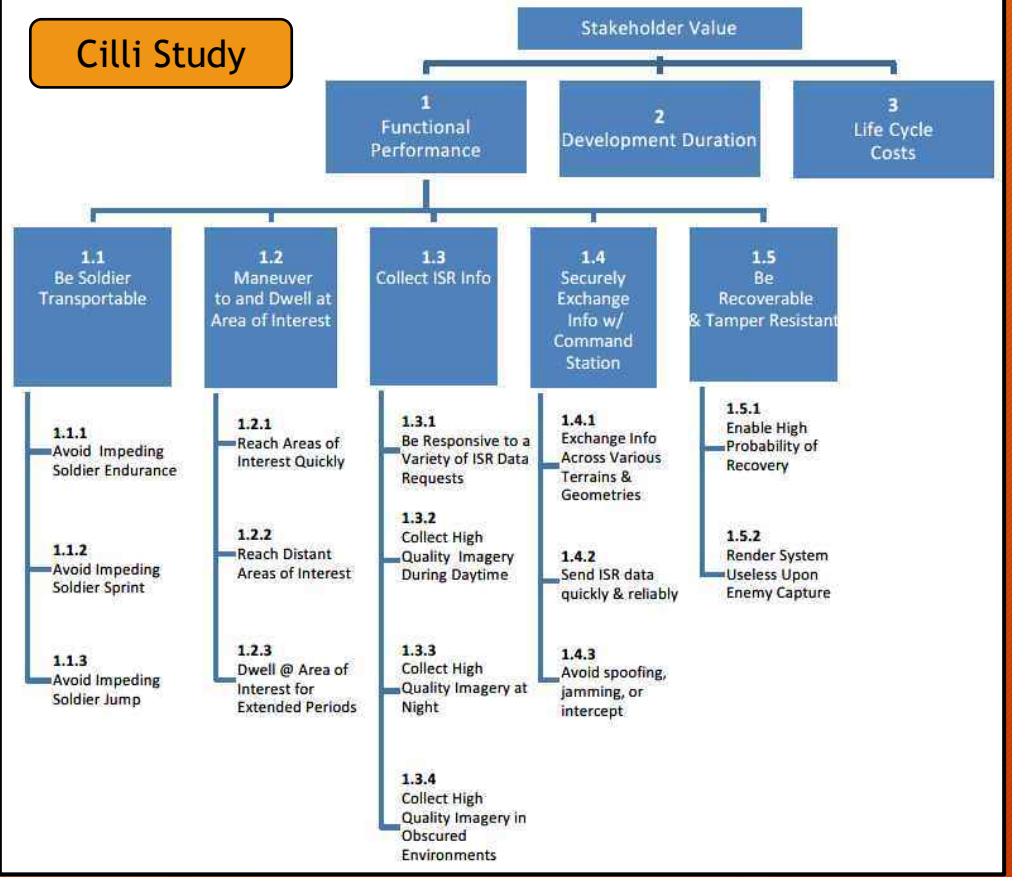
MODA Example Projects

- This presentation illustrates the usage of the Multiple-Objective Decision Analysis (MODA) process in two Unmanned Aerial Vehicle (UAV) Studies described in
  - Cilli, M. (2016) *Improving Defense Acquisition Outcomes Using an Integrated Systems Engineering Decision Management (ISEDM) Approach*, https://www.researchgate.net/publication/XXX
  - Small, C. (2018) *Demonstrating Set-Based Design Techniques – A UAV Case study*, https://www.researchgate.net/publication/XXX
- First, the two different UAV Studies are briefly summarized
  - The two studies differ primarily in the Value Hierarchy developed for each study
  - Which then, of course, affected the remainder of the analysis
- Then, a summary of the MODA process is presented
- Finally, example artifacts from the two studies are used as illustrations of the kinds of artifacts that might be generated in a typical MODA study
- The purpose is to give students an idea of
  - The kinds of artifacts that are generated in a typical MODA study
  - What kind of data is needed to generate the artifacts and support the study
  - How data in the artifacts is arranged (how the artifacts look)
  - How the artifacts fit into the MODA process

Comparison of Qualitative Models between the Two Studies

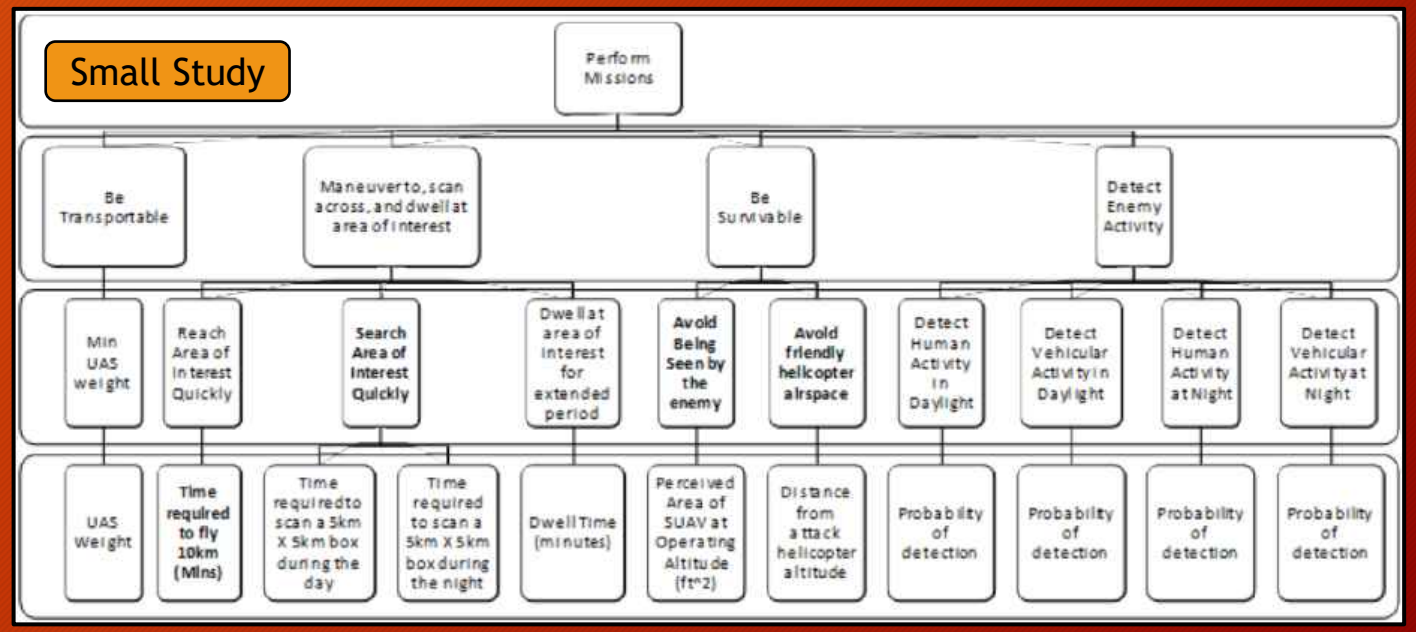
Comparison of Value Hierarchies

Cilli Study



The two studies employed different value hierarchies, even though the general system mission was similar

Small Study



Comparison of Value Measures

Cilli Study

1.1 Be Soldier Transportable	**1.1.1** Avoid Impeding Soldier Endurance	Measure: % decrease in sustainable march speed
	1.1.2 Avoid Impeding Soldier Sprint	Measure: % increase in soldier sprint time
	1.1.3 Avoid Impeding Soldier Jump	Measure: % degredation in soldier jump height
1.2 Maneuver to and Dwell at Area of Interest	**1.2.1** Reach Areas of Interest Quickly	Measure: Max flight speed (km/hour)
	1.2.2 Reach Distant Areas of Interest	Measure: Maximum operational range (km)
	1.2.3 Dwell @ Area of Interest for Extended Periods	Measure: Operational Endurance (hours)
1.3 Collect ISR Info	**1.3.1** Be Responsive to a Variety of ISR Data Requests	Measure: ISR Data Request Responsiveness Index
	1.3.2 Collect High Quality Imagery During Daytime	Measure: TTP rating per NV-IPM @ 3000m full light
	1.3.3. Collect High Quality Imagery at Night	Measure: TTP rating per NV-IPM @ 3000m low light
	1.3.4 Collect High Quality Imagery in Obscured Env.	Measure: TTP rating per NV-IPM @ 3000m w/ smoke
1.4 Securely Exchange Info w/ Command Station	**1.4.1** Exchange Info Across Terrains & Geometries	Measure: BLOS comms capable (yes/no)
	1.4.2 Send large volumes of data quickly & reliably	Measure: High data rate payload comm link? (Y/N)
	1.4.3 Avoid spoofing, jamming, intercept	Measure: Digital C2 link? (Y/N) Digital Payload Com link? (Y/N)
1.5 Be Recoverable & Tamper Resistant	**1.5.1** Enable High Probability of Recovery	Measure: Subjective assessment of landing scheme
	1.7.2 Render System Useless Upon Enemy Capture	Measure: Command self destruct feature?

ISR – Intelligence, Surveillance, and Reconnaissance
TTP – Targeting Task Performance
NV-IPM – Night Vision Integrated Performance Model
C2 – Command and Control
BLOS – Beyond Line of Sight

Small Study

Be Transportable

Function	Be transportable
Value Measure	UAS Weight (lbs.)

Maneuver to, Scan Across, and Dwell at Area of Interest

Function	Maneuver to, scan across, and dwell at area of interest
Value Measure	Time required to fly 10km (Mins)

Function	Maneuver to, scan across, and dwell at area of interest
Value Measure	Time required to scan a 5km X 5km box during the day (Mins.)

Function	Maneuver to, scan across, and dwell at area of interest
Value Measure	Time required to scan a 5km X 5km box during the night (Mins.)

Function	Maneuver to, scan across, and dwell at area of interest
Value Measure	Dwell time (Mins.)

Be Survivable

Function	Be Survivable
Value Measure	Percieved Area of SUAV at Operating Altitude (ft^2)

Avoid Friendly Helicopter Airspace

Function	Avoid friendly helicopter airspace
Value Measure	Difference between operating altitude and attack helicopter operating altitude of 1000m (Mtrs.)

Detect Enemy Activity

Function	Detect Enemy Activity
Value Measure	Probability of detection-Detect Human Activity in Daylight [0.0 – 1.0]

Function	Detect Enemy Activity
Value Measure	Probability of detection-Detect Vehicular Activity in Daylight [0.0 – 1.0]

Function	Detect Enemy Activity
Value Measure	Probability of detection-Detect Human Activity at Night [0.0 – 1.0]

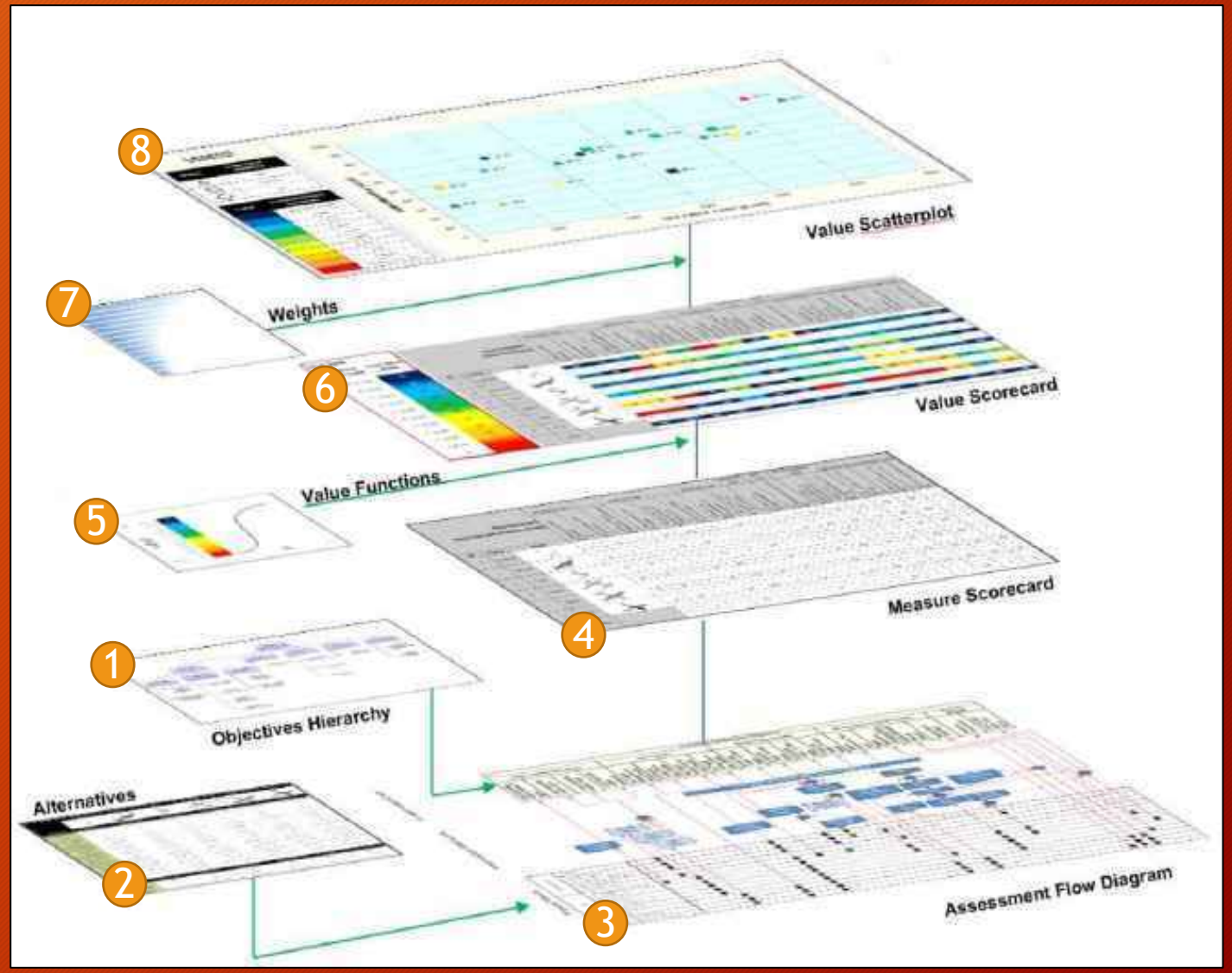
Function	Detect Enemy Activity
Value Measure	Probability of detection-Detect Vehicular Activity at Night [0.0 – 1.0]

UAS – Unmanned Aerial System
SUAV - Small Unmanned Aerial Vehicles

Summary of the MODA Process as described in Cilli Study

Cilli Study MODA Process Overview

1. Develop Value (Objectives) Hierarchy
2. Develop Alternatives
3. Incorporate Value Hierarchy and Alternatives into Assessment Flow Diagram
4. Develop Measure Scorecard
5. Develop Value Functions
6. Apply Value Functions to Measure Scorecard to produce Value Scorecard
7. Develop Weights
8. Apply Weights to Value Scorecard to produce Value Scatterplot

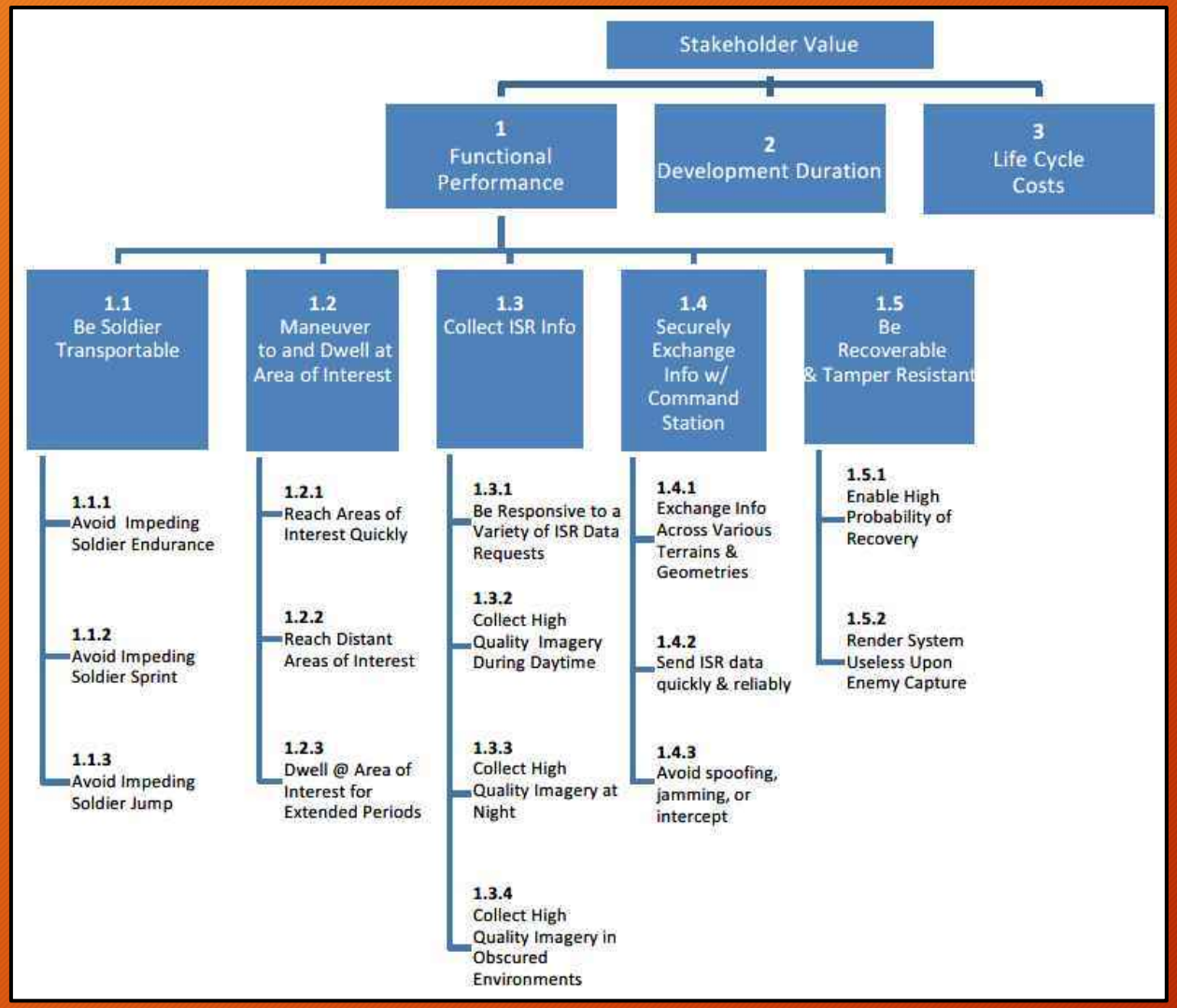


Uncertainty is not covered in this lecture due to time constraints

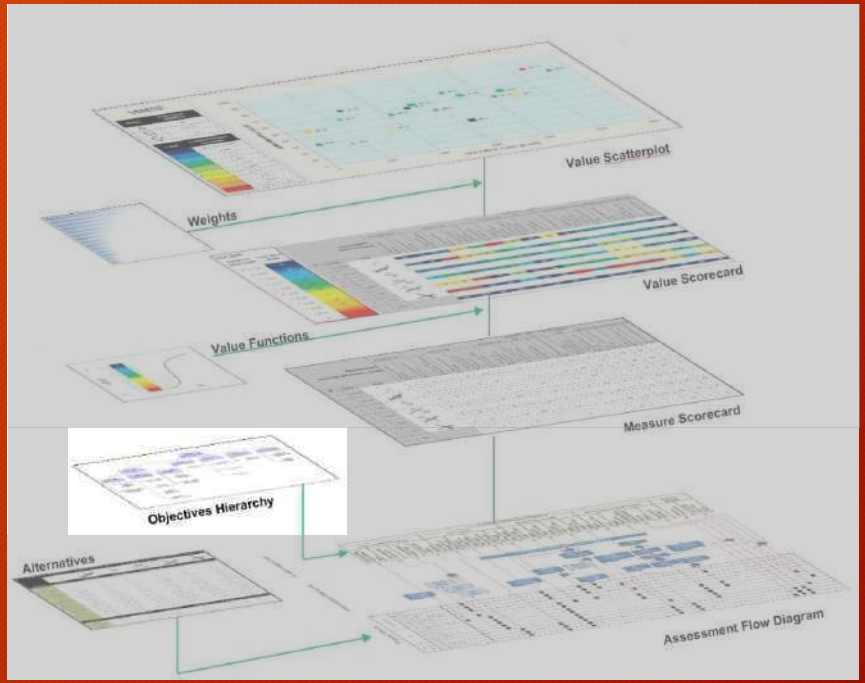
Artifacts that Might be Generated in a Typical MODA Study

Develop Value (Objective) Hierarchy

- As seen in previous chart for Cilli Study…



Cilli Study MODA Process Overview



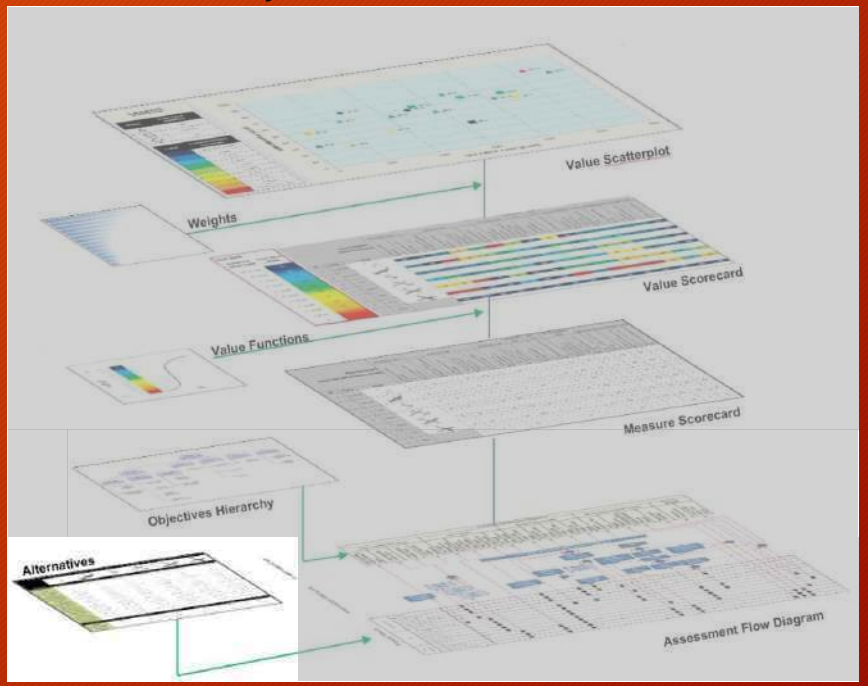
Develop Alternatives

- In the Cilli Study, the options considered for each system element were identified
  - Here, for the Air Vehicle

Air Vehicle

Propulsion System	Energy Source	Prop Size & Location	Wing Span	Wing Config.	Fin Config.	Actuators	Airframe Material	Autopilot	Launch
Electric 300W	Li-Ion Battery	18" Rear	4 ft	Conv.	Twin Boom Conv.	Electro-magnetic	Graphite Epoxy	Pre-Program, Auto	Hand
Electric 600W	Li-S Battery	22" Rear	5 ft	Canard	Inverted V	Hydraulic	Aramid Epoxy	Semi-Auto	Tensioned Line
Piston Engine 2.5HP	Fuel Cell	26" Rear	6 ft	Tandem Wing	V Tail	MEMS	Boron Epoxy	Remotely Piloted	Gun Launch
Piston Engine 4.0HP	Solar	18" Front	7 ft	Three Surface	H Tail		Fiberglass Epoxy		
	JP-8 Fuel	22" Front	8 ft		Cruciform				
		26" Front	9 ft						

Cilli Study MODA Process Overview

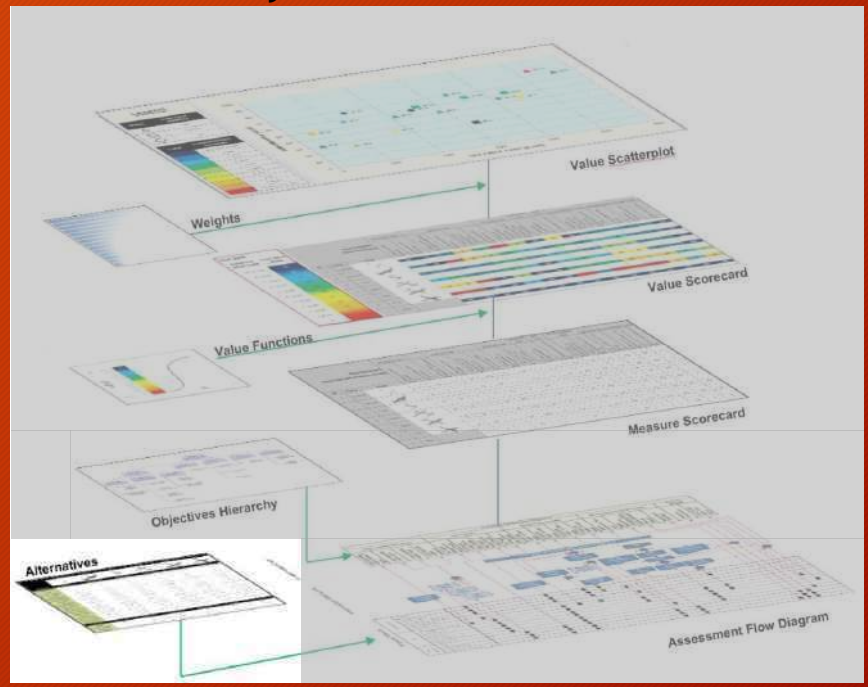


Develop Alternatives (continued)

- In the Cilli Study, the options considered for each system element were identified, here for the
  - ISR Collecting Payload
  - Communication Links
  - Ground Elements

ISR Collecting Payload			Communication Links		Ground Elements			
Sensor Actuation	EO Imager	IR Imager	Command & Control Link	Payload Link	Antenna	Computer	User Input Device	Power
Fixed	none	none	Small Fixed Antenna transmit analog data direct to GCS (VHF or UHF)	Small Fixed Antenna transmit analog data direct to GCS (VHF or UHF)	Dipole	Ruggedized Laptop	Keyboard	Generator
Pan-tilt	4 Megapixel Daylight Camera	Cooled 320 x 240 MWIR	Small, Fixed, Non-pointing Antenna transmit digital data to LEO Satellite (L Band)	Small, Fixed, Non-pointing Antenna transmit digital data to LEO Satellite (L Band)	Parabolic Reflector	Wearable Computer	Joystick	Battery + Generator
Roll-tilt	8 Megapixel Daylight Camera	Cooled, 640 x 480 MWIR		Mech. Steerable parabolic dish transmit digital data to GEO Satellite (Ka or Ku Band)		Smart-phone	Touchscreen	Battery + Backup Batteries
Pan-tilt-roll		Cooled 1280 x 720 MWIR & LWIR		Electronically Steered Phased Array Antenna transmit digital data to GEO Satellite (Ka or Ku Band)			Stylus	
		Uncooled 1024 x 768 MWIR & LWIR						

Cilli Study MODA Process Overview

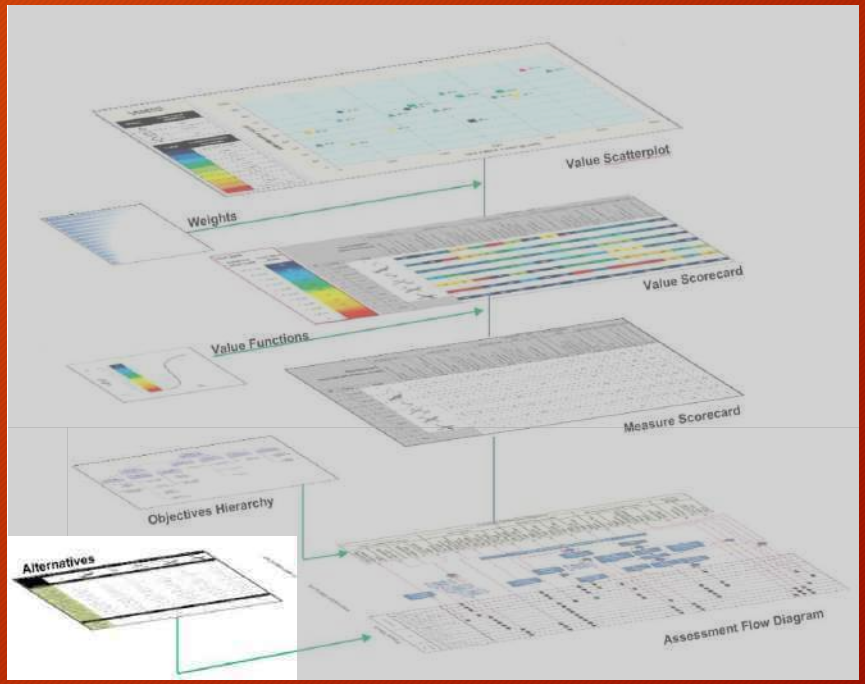


Develop Alternatives (continued)

The identification of system element options led to the development of the 12 study alternatives

Subsystem / Component	1 Buzzard I	2 Buzzard II	3 Cardinal I	4 Cardinal II
				
	Design Choice	Design Choice	Design Choice	Design Choice
Air Vehicle				
Propulsion System	Electric 300W	Electric 300W	Electric 300W	Electric 300W
Energy Source	Li-Ion Battery	Li-Ion Battery	Li-S Battery	Li-S Battery
Prop Size & Location	18" Rear	18" Rear	20" Rear	20" Rear
Wing Span	5'	5'	6'	6'
Wing Configuration	Canard	Canard	Conventional	Conventional
Fin Configuration	Inverted V	Inverted V	Twin Boom	Twin Boom
Actuators	Electromagnetic	Electromagnetic	Electromagnetic	Electromagnetic
Airframe Material	Graphite Epoxy	Graphite Epoxy	Graphite Epoxy	Graphite Epoxy
Autopilot	Semi-Auto	Semi-Auto	Remotely Piloted	Remotely Piloted
Launch Mechanism	Hand	Hand	Hand	Hand
ISR Collecting Payload				
Sensor Actuation	Fixed	Fixed	Fixed	Fixed
EO Imager	4 MP	4 MP	4 MP	4 MP
IR Imager	320 x 240 MWIR	640 x 480 MWIR	320 x 240 MWIR	640 x 480 MWIR
Communication Links				
Command & Control Link	Fixed VHF	Fixed VHF	Fixed VHF	Fixed VHF
Payload Data Link	Fixed VHF	Fixed VHF	Fixed VHF	Fixed VHF
Ground Elements				
Antenna	Dipole	Dipole	Dipole	Dipole
Computer	Laptop	Laptop	Smartphone	Smartphone
User Input Device	Keyboard	Keyboard	Joystick	Joystick
Power	Battery + Spare	Battery + Spare	Battery + Spare	Battery + Spare

Cilli Study MODA Process Overview

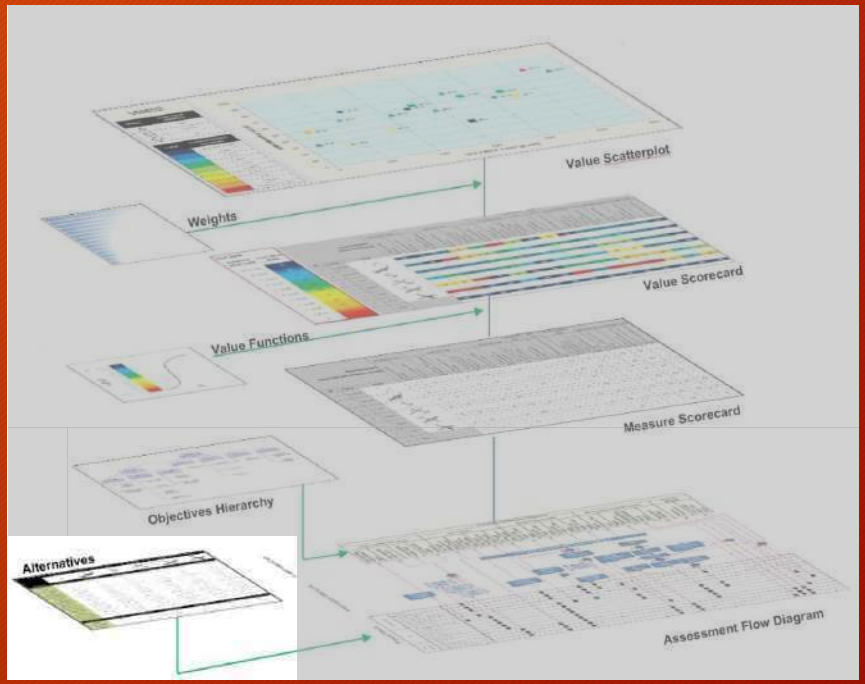


Develop Alternatives (continued)

The identification of system element options led to the development of the 12 study alternatives

Subsystem / Component	5 Crow I	6 Crow II	7 Pigeon I	8 Pigeon II
				
	Design Choice	Design Choice	Design Choice	Design Choice
Air Vehicle				
Propulsion System	Electric 600W	Electric 600W	Electric 600W	Electric 600W
Energy Source	Li-Ion Battery	Li-Ion Battery	Li-S Battery	Li-S Battery
Prop Size & Location	22" Rear	22" Rear	20" Rear	20" Rear
Wing Span	6'	6'	6'	6'
Wing Configuration	Tandem Wing	Tandem Wing	Conventional	Conventional
Fin Configuration	V Tail	V Tail	Twin Boom	Twin Boom
Actuators	MEMS	MEMS	Electromagnetic	Electromagnetic
Airframe Material	Graphite Epoxy	Graphite Epoxy	Graphite Epoxy	Graphite Epoxy
Autopilot	Semi-Auto	Semi-Auto	Remotely Piloted	Remotely Piloted
Launch Mechanism	Hand	Hand	Hand	Hand
ISR Collecting Payload				
Sensor Actuation	Pan-tilt	Pan-tilt	Pan-tilt	Pan-tilt
EO Imager	8 MP	8 MP	8 MP	8 MP
IR Imager	1280 x 720 MWIR & LWIR cooled	1280 x 720 MWIR & LWIR uncooled	1280 x 720 MWIR & LWIR cooled	1280 x 720 MWIR & LWIR uncooled
Communication Links				
Command & Control Link	Fixed VHF	Fixed VHF	Fixed VHF	Fixed VHF
Payload Data Link	Fixed VHF	Fixed VHF	Phased Array Ka	Phased Array Ka
Ground Elements				
Antenna	Dipole	Dipole	Dipole & Dish	Dipole & Dish
Computer	Laptop	Laptop	Laptop	Laptop
User Input Device	Keyboard	Keyboard	Joystick	Joystick
Power	Battery + Spare	Battery + Spare	Battery + Spare	Battery + Spare

Cilli Study MODA Process Overview

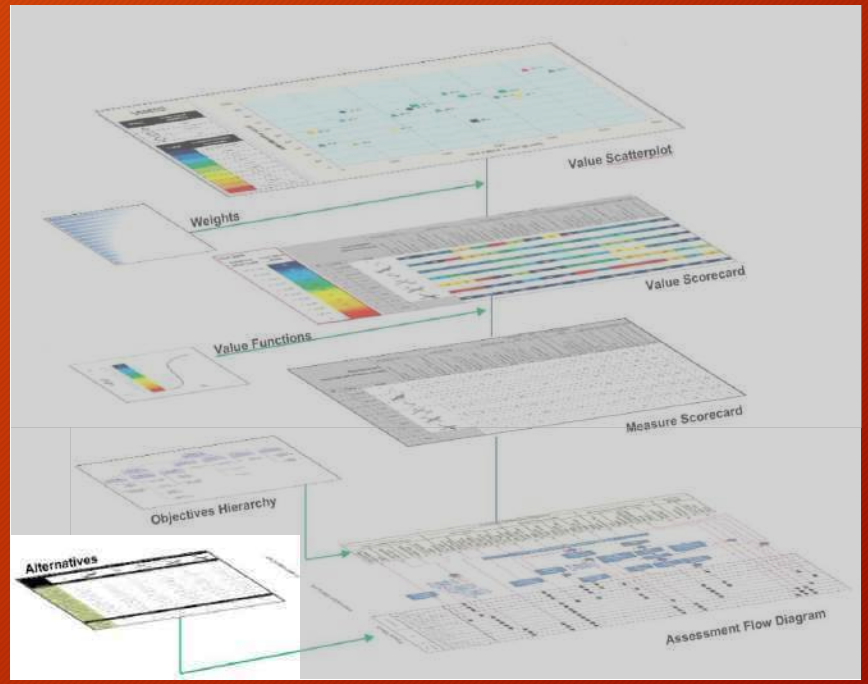


Develop Alternatives (continued)

The identification of system element options led to the development of the 12 study alternatives

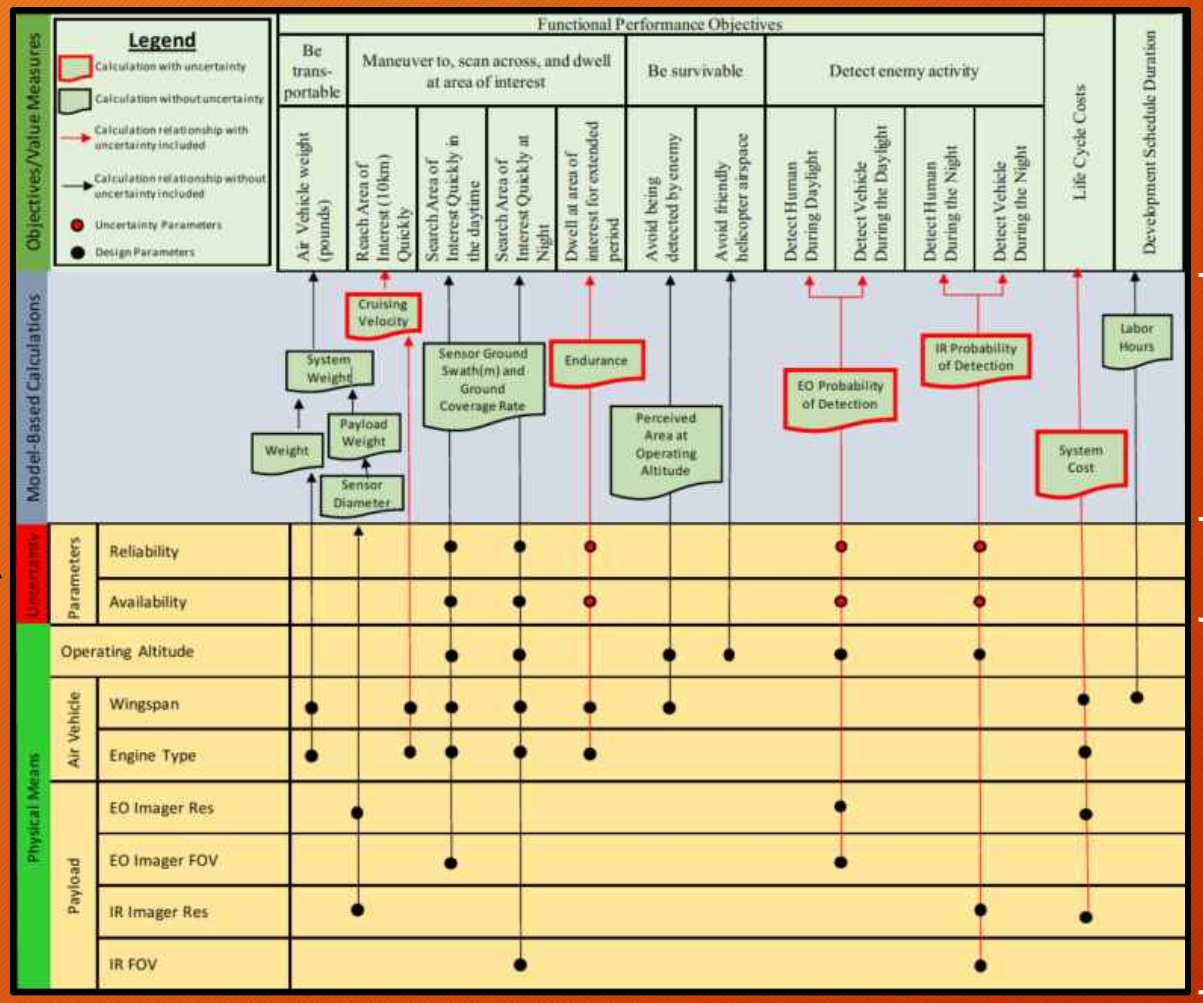
	9 Robin I	10 Robin II	11 Dove I	12 Dove II
				
Subsystem / Component	Design Choice	Design Choice	Design Choice	Design Choice
Air Vehicle				
Propulsion System	Piston 2.5 HP	Piston 2.5 HP	Piston 4.0 HP	Piston 4.0 HP
Energy Source	JP-8	JP-8	JP-8	JP-8
Prop Size & Location	26" Front	26" Front	28" Front	28" Front
Wing Span	8'	8'	9'	9'
Wing Configuration	Conventional	Conventional	Conventional	Conventional
Fin Configuration	H Tail	H Tail	Cruciform	Cruciform
Actuators	Hydraulic	Hydraulic	Hydraulic	Hydraulic
Airframe Material	Fiberglass Epoxy	Fiberglass Epoxy	Fiberglass Epoxy	Fiberglass Epoxy
Autopilot	Remotely Piloted	Remotely Piloted	Remotely Piloted	Remotely Piloted
Launch Mechanism	Tensioned Line	Tensioned Line	Tensioned Line	Tensioned Line
ISR Collecting Payload				
Sensor Actuation	Pan-tilt	Pan-tilt	Pan-tilt	Pan-tilt
EO Imager	8 MP	8 MP	8 MP	8 MP
IR Imager	1280 x 720 MWIR & LWIR cooled	1280 x 720 MWIR & LWIR uncooled	1280 x 720 MWIR & LWIR cooled	1280 x 720 MWIR & LWIR uncooled
Communication Links				
Command & Control Link	Fixed VHF	Fixed VHF	Fixed VHF	Fixed VHF
Payload Data Link	Elect. Steered Phased Array Ka	Elect. Steered Phased Array Ka	Mech. Steered Dish Ka	Mech. Steered Dish Ka
Ground Elements				
Antenna	Dipole	Dipole	Dipole & Dish	Dipole & Dish
Computer	Laptop	Laptop	Laptop	Laptop
User Input Device	Keyboard	Keyboard	Joystick	Joystick
Power	Battery + Gen.	Battery + Gen.	Battery + Gen.	Battery + Gen.

Cilli Study MODA Process Overview



Incorporate Value Hierarchy and Alternatives into Assessment Flow Diagram

Value Hierarchy



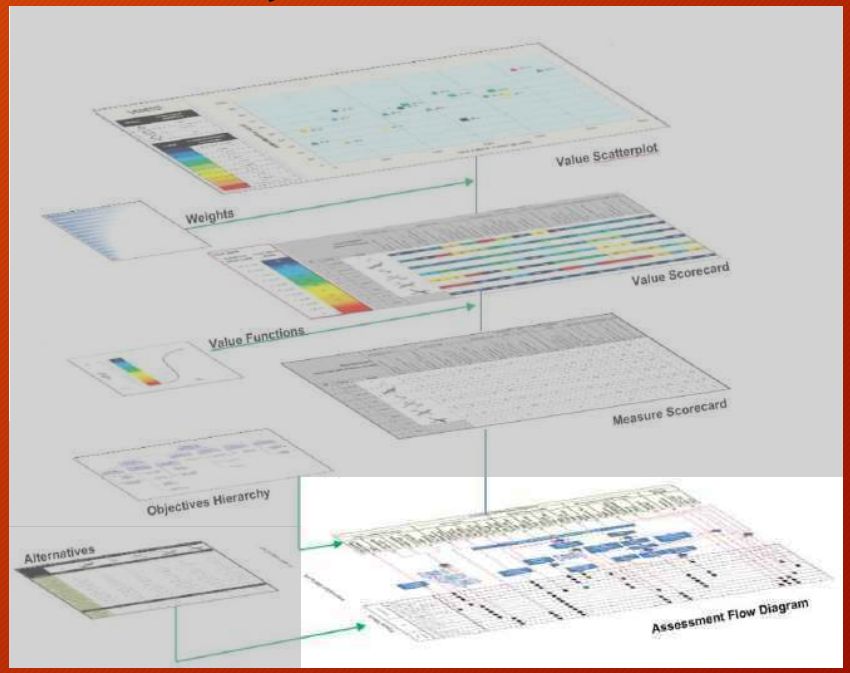
Model-Based Systems Engineering (MBSE), Lab Testing, Field Testing, Operational Data, etc, are used to determine the performance of the system under each possible component configuration

Alternative Component Configurations

The purpose here is to show how each system component contributes to the assessment of value measures

This Assessment Flow Diagram comes from the Small Study

Cilli Study MODA Process Overview

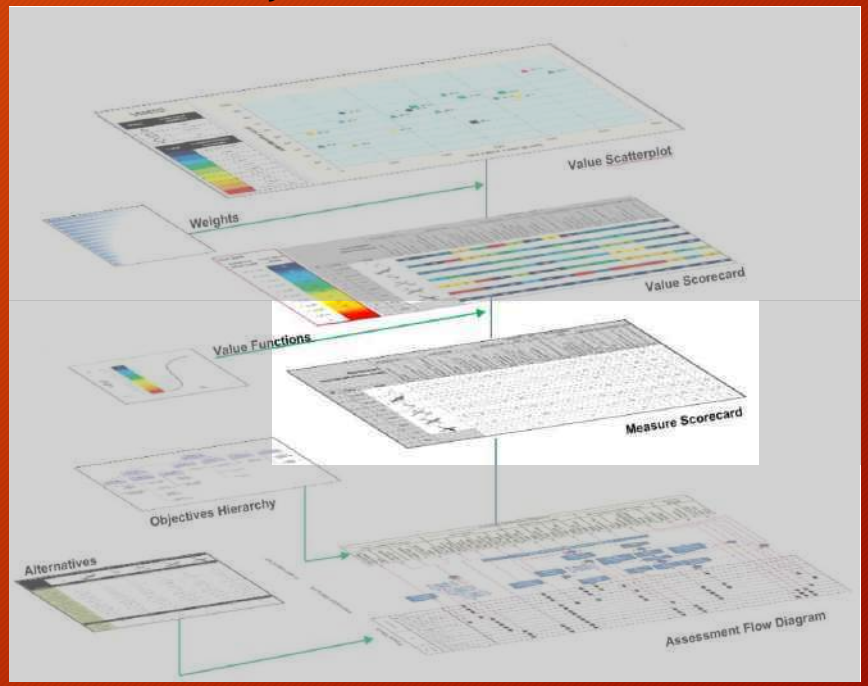


* Uncertainty is not covered in this lecture due to time constraints

Develop Measure Scorecard

1.1 Be Soldier Transportable	**1.1.1** Avoid Impeding Soldier Endurance	Measure: % decrease in sustainable march speed
	1.1.2 Avoid Impeding Soldier Sprint	Measure: % increase in soldier sprint time
	1.1.3 Avoid Impeding Soldier Jump	Measure: % degredation in soldier jump height
1.2 Maneuver to and Dwell at Area of Interest	**1.2.1** Reach Areas of Interest Quickly	Measure: Max flight speed (km/hour)
	1.2.2 Reach Distant Areas of Interest	Measure: Maximum operational range (km)
	1.2.3 Dwell @ Area of Interest for Extended Periods	Measure: Operational Endurance (hours)
1.3 Collect ISR Info	**1.3.1** Be Responsive to a Variety of ISR Data Requests	Measure: ISR Data Request Responsiveness Index
	1.3.2 Collect High Quality Imagery During Daytime	Measure: TTP rating per NV-IPM @ 3000m full light
	1.3.3. Collect High Quality Imagery at Night	Measure: TTP rating per NV-IPM @ 3000m low light
	1.3.4 Collect High Quality Imagery in Obscured Env.	Measure: TTP rating per NV-IPM @ 3000m w/ smoke
1.4 Securely Exchange Info w/ Command Station	**1.4.1** Exchange Info Across Terrains & Geometries	Measure: BLOS comms capable (yes/no)
	1.4.2 Send large volumes of data quickly & reliably	Measure: High data rate payload comm link? (Y/N)
	1.4.3 Avoid spoofing, jamming, intercept	Measure: Digital C2 link? (Y/N) Digital Payload Com link? (Y/N)
1.5 Be Recoverable & Tamper Resistant	**1.5.1** Enable High Probability of Recovery	Measure: Subjective assessment of landing scheme
	1.7.2 Render System Useless Upon Enemy Capture	Measure: Command self destruct feature?

Cilli Study MODA Process Overview



These are the value measures from the Cilli Study by which the alternatives will be measured

Develop Measure Scorecard

			Functional Performance																	
			Be Transported			Fly			Collect					Communicate			End			
			Avoid Impeding Soldier Endurance	Avoid Impeding Soldier Sprint	Avoid Impeding Soldier Jump	Reach Area of Interest (10km) Quickly	Reach Distant Areas of Interest	Dwell at Area of Interest	Be Responsive to a Variety of ISR Data Requests	Collect High Quality Imagery During Day	Collect High Quality Imagery During Night	Collect High Quality Imagery In Obscured Environments	Exchange Info Across Various Terrains & Geometries	Send ISR Imagery Quickly and Reliably	Avoid spoofing, jamming, or communicate intercept	Enable High Probability of Recovery	Render System Useless Upon Enemy Capture	Life Cycle Costs	Development Schedule Duration
ID	Name	Image	%	%	%	min	km	hrs	VI	P_d	P_d	P_d	LB	s	AD	%	yn	$B	yr
1	*Buzzard I*		1	2	3	15	10	1	2	0.3	0.2	0.1	L	30	A	90	Y	1	2
2	*Buzzard II*		1	2	3	15	10	1	4	0.4	0.3	0.2	L	30	A	90	Y	1.5	2
3	*Cardinal I*		2	4	5	12	12	1.5	5	0.5	0.4	0.3	L	90	A	90	Y	2.3	3
4	*Cardinal II*		2	4	5	12	12	1.5	10	0.5	0.4	0.3	L	90	A	90	Y	4	3
5	*Crow I*		4	5	8	10	15	5	10	0.9	0.8	0.7	B	20	D	95	Y	5	9
6	*Crow II*		3	4	7	9	15	6	10	0.8	0.7	0.6	B	30	D	95	Y	6	9
7	*Pigeon I*		5	7	10	8	18	8	10	0.9	0.8	0.7	B	20	D	95	Y	6.5	7
8	*Pigeon II*		4	6	9	7	18	9	10	0.8	0.7	0.6	B	30	D	95	Y	7.5	7
9	*Robin I*		7	12	17	6	22	10	10	0.9	0.8	0.7	B	20	D	98	Y	8.3	6
10	*Robin II*		6	11	16	6	22	11	10	0.8	0.7	0.6	B	30	D	98	Y	8.8	6
11	*Dove I*		10	15	20	4	30	23	10	0.9	0.8	0.7	B	20	D	98	Y	9.3	5
12	*Dove II*		9	14	19	4	30	24	10	0.8	0.7	0.6	B	30	D	98	Y	9.9	5

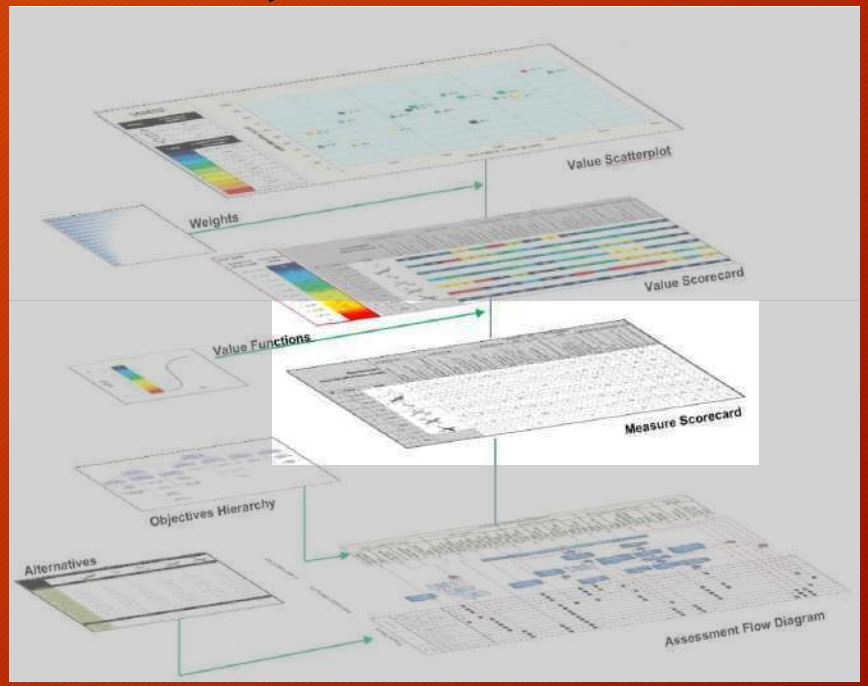
Value Measures

Scores for all Alternatives vs all Value Measures

Score for Alternative 10 against value measure Life Cycle Cost

SMEs determine the value scores for each configuration for each value measure

Cilli Study MODA Process Overview



Develop Value Functions

- **Walk Away**: stakeholder will dismiss an alternative if it fails to meet at least this level regardless of how it performance on other value measures (0 points).
- **Marginally Acceptable**: Stakeholder begins to become interested and beyond this point the perceived value increases rapidly (10 points).
- **Target**: Desired level (50 points)
- **Stretch Goal**: Improving beyond this point is considered gold plating so there is very little available value between this point and meaningful limit (90 points).
- **Meaningful Limit**: Theoretical limit or known practical limit beyond which would be considered nonsense (100 points).

		Functional Performance														
		Be Transported			Fly			Collect				Communicate			End	
Value Measures		Avoid Impeding Soldier Endurance	Avoid Impeding Soldier Sprint	Avoid Impeding Soldier Jump	Reach Area of Interest (10km) Quickly	Reach Distant Areas of Interest	Dwell at Area of Interest	Be Responsive to a Variety of ISR Data Requests	Collect High Quality Imagery During Day	Collect High Quality Imagery During Night	Collect High Quality Imagery In Obscured Environments	Exchange Info Across Various Terrains & Geometries	Send ISR Imagery Quickly and Reliably	Avoid spoofing, jamming, or communicate intercept	Enable High Probability of Recovery	Render System Useless Upon Enemy Capture
Name	Value	%	%	%	min	km	hrs	VI	P_d	P_d	P_d	L/B	sec	A/D	%	y/n
Walk-Away	1	10	15	20	15	10	1	1	0.1	0.1	0.1	-	90	-	90	-
Marginally Acceptable	10	8	12	16	12	15	2	2	0.2	0.2	0.2	L	30	A	92	N
Target	50	5	7.5	10	8	30	4	5	0.7	0.7	0.7	-	10	-	95	-
Stretch Goal	90	2	3	4	4	45	8	8	0.9	0.9	0.9	B	5	D	98	Y
Meaningful Limit	100	0	0	0	1	50	16	10	1.0	1.0	1.0	-	1	-	100	-

Values (0-100)

Y-Axis of Value Function

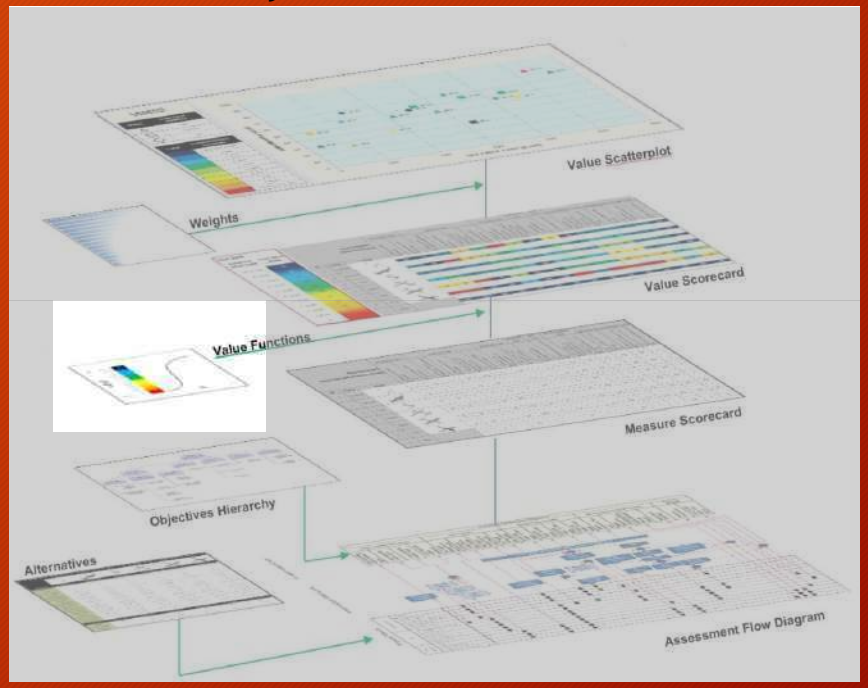
Used in all Value Functions

Value Scores

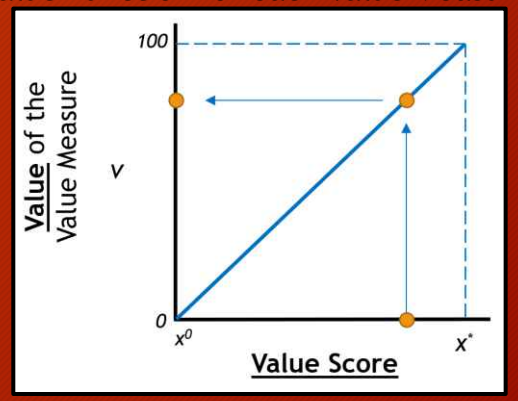
X-Axis of Value Function

Used in each Individual Value Measure

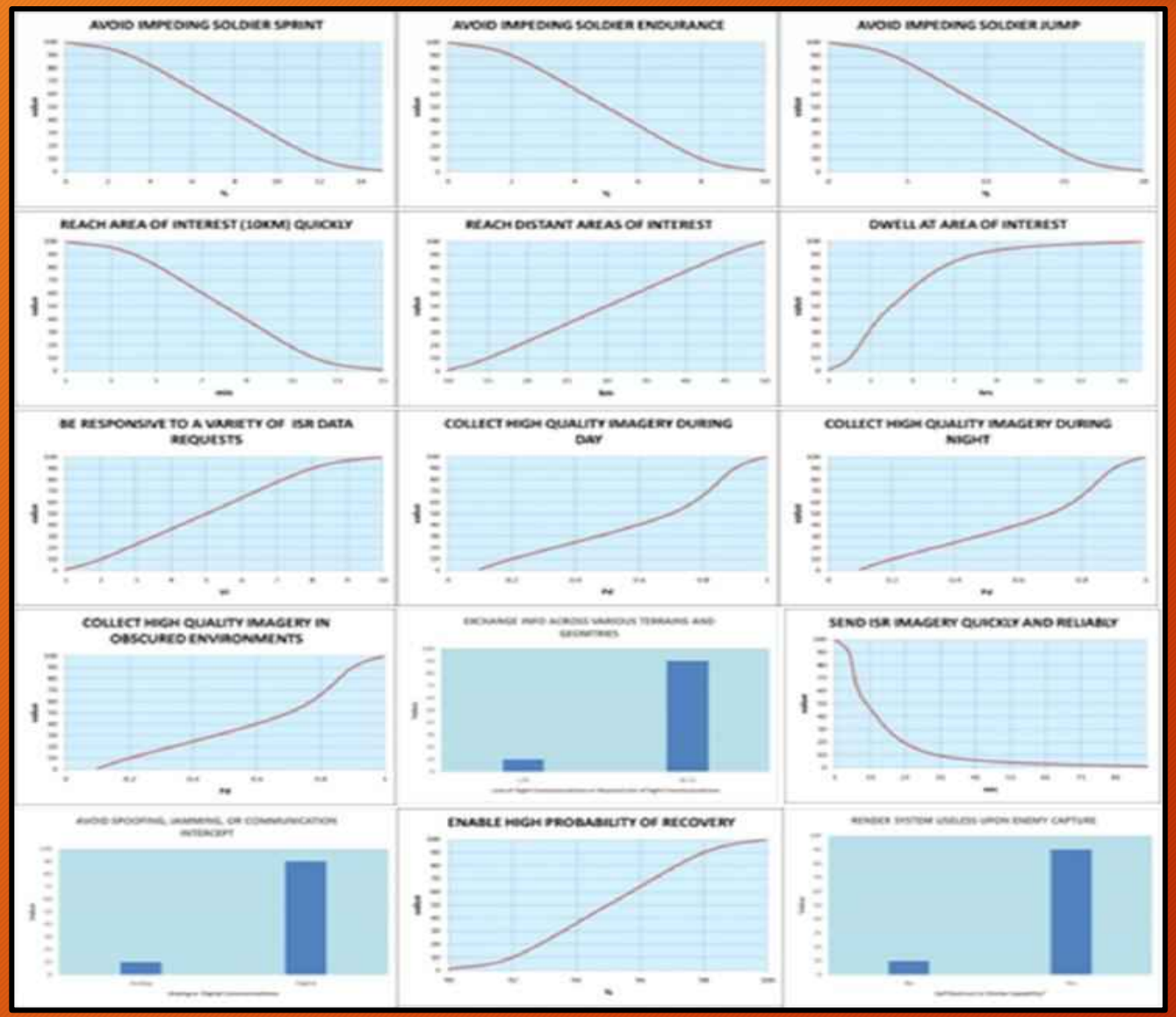
Cilli Study MODA Process Overview



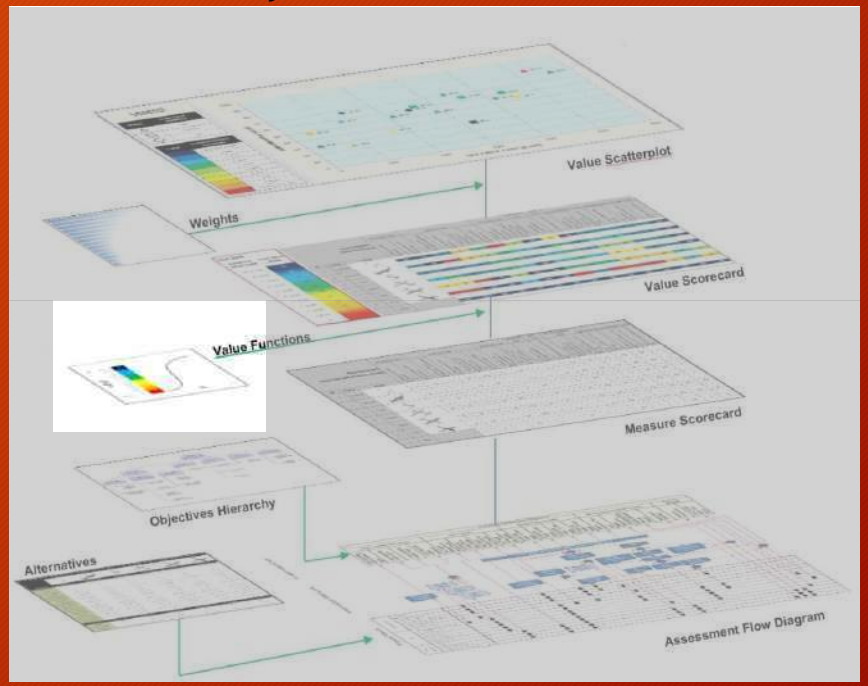
Value Function for each Value Measure



Develop Value Functions (continued)



Cilli Study MODA Process Overview



These are the resulting value functions from the Cilli Study

One for each value measure

Apply Value Functions to Measure Scorecard to produce Value Scorecard

			Functional Performance																
			Be Transported			Fly			Collect				Communicate			End			
			Avoid Impeding Soldier Endurance	Avoid Impeding Soldier Sprint	Avoid Impeding Soldier Jump	Reach Area of Interest (10km) Quickly	Reach Distant Areas of Interest	Dwell at Area of Interest	Be Responsive to a Variety of ISR Data Requests	Collect High Quality Imagery During Day	Collect High Quality Imagery During Night	Collect High Quality Imagery In Obscured Environments	Exchange Info Across Various Terrains & Geometries	Send ISR Imagery Quickly and Reliably	Avoid spoofing, jamming, or communicate intercept	Enable High Probability of Recovery	Render System Useless Upon Enemy Capture	Life Cycle Costs	Development Schedule Duration
ID	Name	Image	%	%	%	min	km	hrs	VI	P_d	P_d	P_d	LB	sec	AD	%	y/n	$B	yrs
1	*Buzzard I*		95	93	92	1	1	1	10	18	10	1	10	10	10	1	90	100	90
2	*Buzzard II*		95	93	92	1	1	1	37	26	18	10	10	10	10	1	90	95	90
3	*Cardinal I*		90	81	83	10	5	6	50	34	26	18	10	1	10	1	90	86	77
4	*Cardinal II*		90	81	83	10	5	6	100	34	26	18	10	1	10	1	90	63	77
5	*Crow I*		63	72	63	30	10	60	100	90	70	50	90	30	90	50	90	50	6
6	*Crow II*		77	81	70	40	10	70	100	70	50	42	90	10	90	50	90	37	6
7	*Pigeon I*		50	54	50	50	18	90	100	90	70	50	90	30	90	50	90	30	23
8	*Pigeon II*		63	63	57	60	18	91	100	70	50	42	90	10	90	50	90	17	23
9	*Robin I*		23	10	8	70	29	92	100	90	70	50	90	30	90	90	90	7	37
10	*Robin II*		37	19	10	70	29	94	100	70	50	42	90	10	90	90	90	8	37
11	*Dove I*		1	1	1	90	50	100	100	90	70	50	90	30	90	90	90	1	50
12	*Dove II*		6	4	3	90	50	100	100	70	50	42	90	10	90	90	90	1	50

Value Measures

These are the resulting values

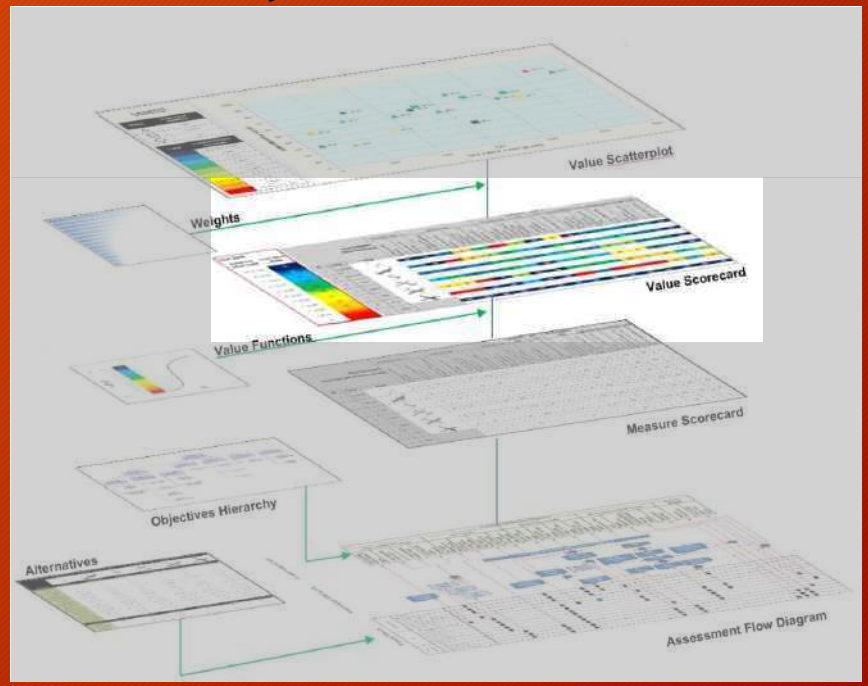
They are determined by using the value functions for each value measure to convert the value scores to values (0-100)

One value for each alternative for each value measure

Values for all Alternatives vs all Value Measures

Value for Alternative 10 against value measure Life Cycle Cost

Cilli Study MODA Process Overview



Develop Weights

Swing Weight Matrix from Small Study

Weight Importance

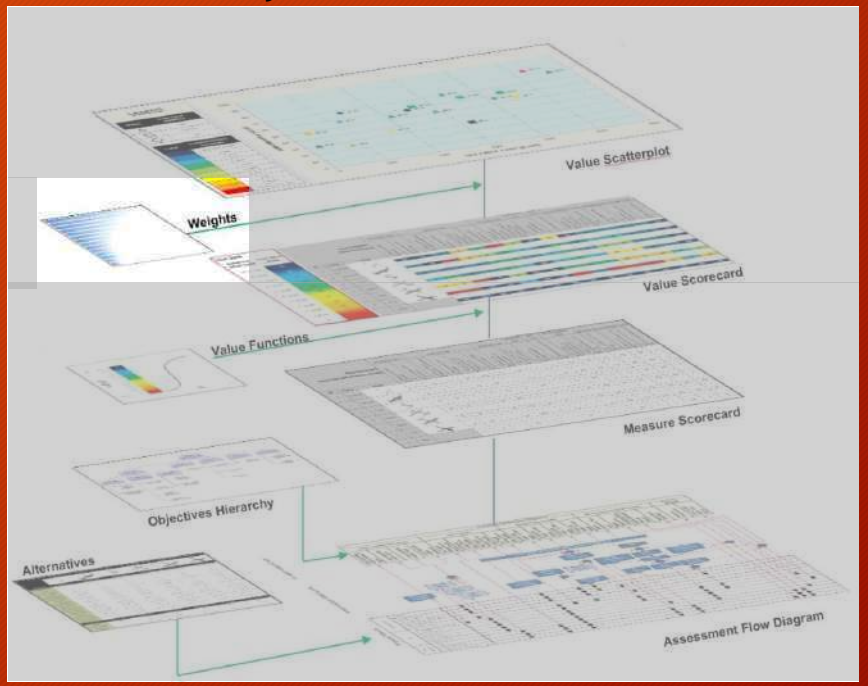
Weight Variation

	Critical to mission			Important to mission			Fixable with dollars		
		fi	wi		fi	wi	Assessed fi	fi	wi
Significant impact of performance variation	Probability of detecting a vehicle night	100	0.14	Probability of detecting a human day	75	0.10	Time Required to scan night	60	0.08
	Probability of detecting a vehicle day	99	0.14				Time Required to scan day	50	0.07
	Probability of detecting a human night	98	0.14				Difference from attack helicopter altitude	50	0.07
Some impact of site variation				Time required to fly 10km (Mins)	60	0.08	Percieved Area of SUAV at Altitude	20	0.03
				Dwell Time (Mins)	60	0.08			
				UAS Weight	50	0.07			
Minor impact of site variation									

Raw Weights Normalized Weights

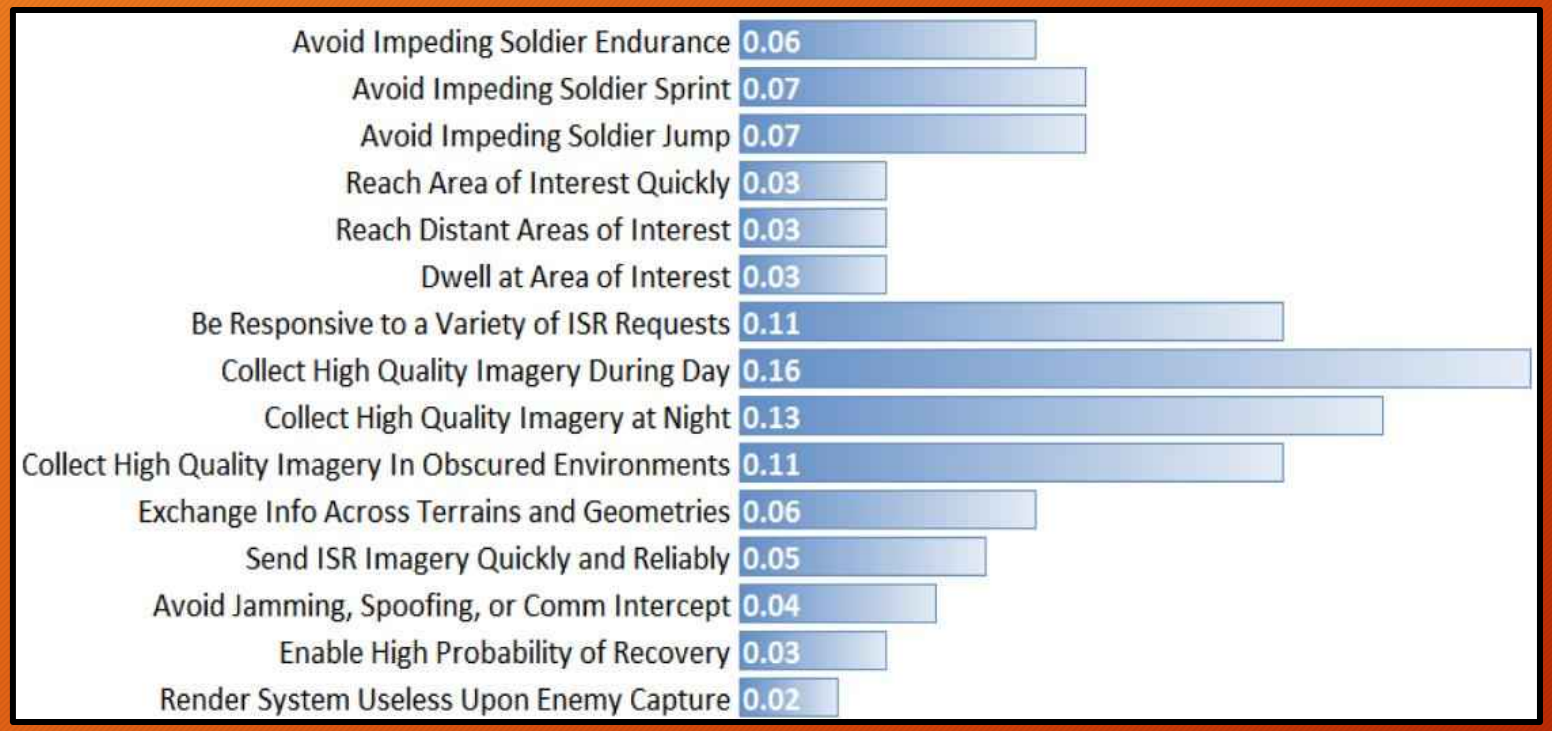
All normalized weights must sum to 1

Cilli Study MODA Process Overview



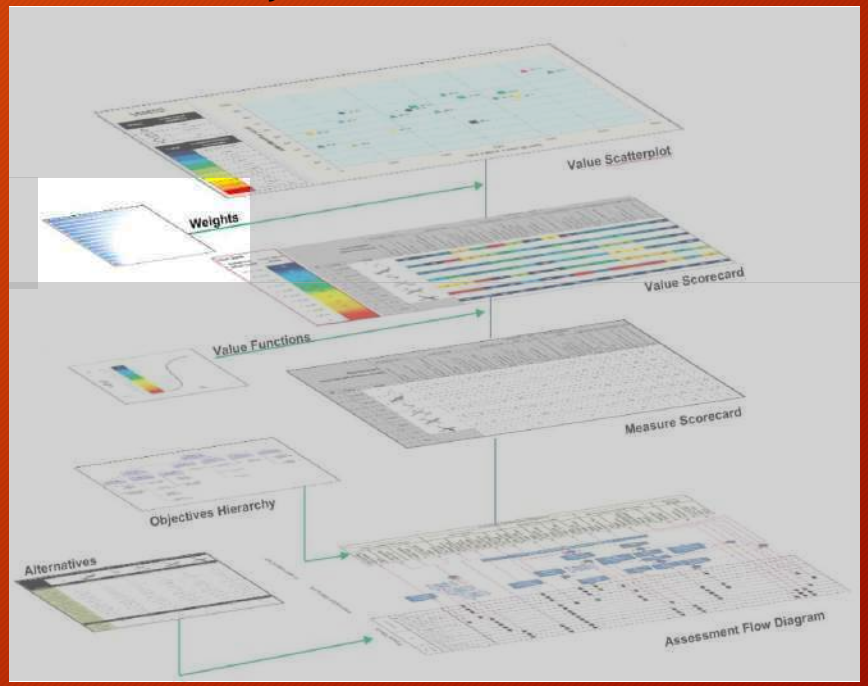
Develop Weights (continued)

Normalized Weights from Cilli Study



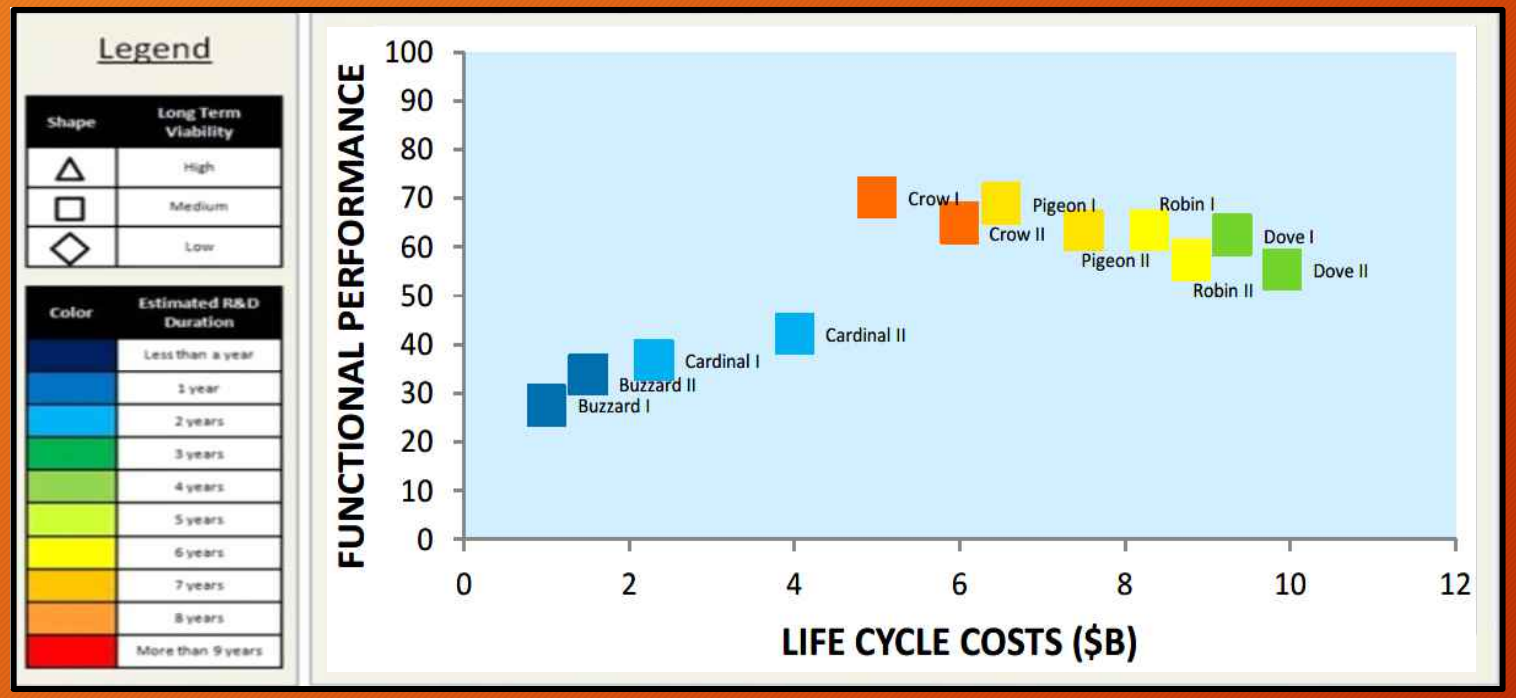
All normalized weights must sum to 1

Cilli Study MODA Process Overview



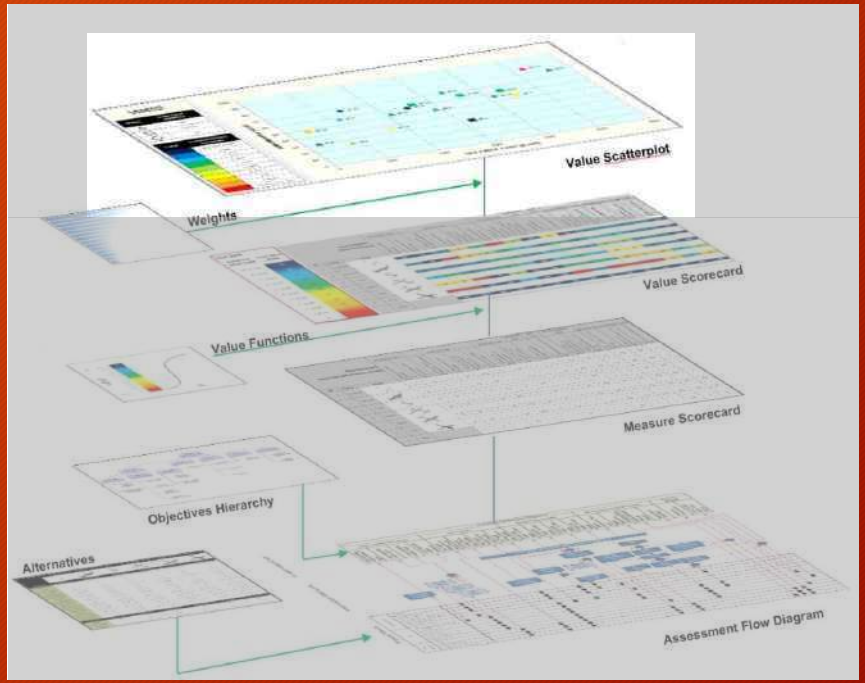
Apply Weights to Value Scorecard to produce Value Scatterplot

Value Scatterplot from Cilli Study



* Uncertainty bars are not shown here since uncertainty is not covered in this lecture due to time constraints

Cilli Study MODA Process Overview



This is the final product of the MODA Study

This is produced by using the Additive Value Function to come up with a final value for each alternative

The alternatives are plotted using their final values versus cost to determine which alternative has the best value for the least cost

References

- Small, C.; Parnell, G.; Pohl, E.; Goerger, S.; Cilli, M.; Specking, E. (2019). *Demonstrating set-based design techniques: an unmanned aerial vehicle case study,* https://www.researchgate.net/publication/XXX
- Cilli, M. (2016) *Improving Defense Acquisition Outcomes Using an Integrated Systems Engineering Decision Management (ISEDM) Approach*, https://www.researchgate.net/publication/XXX