

IPT2004 Competition Sensitive Document Attached

Team 4

The Attached Document is Competition Sensitive until May 5, 2004.

If you find this document and do not know what to do with it,

put it in a secure place and notify

Dr. Robert A. Frederick, Jr.
Associate Professor
The University of Alabama in Huntsville
256-824-7203
frederic@eng.uah.edu

Alternate Concepts White Paper

IPT 4

Project Office:
Systems Engineering
Seekers and Guidance
Navigation/Power Supply
Modeling and Simulation
Control
Advanced Analysis
Launch Platform/ Prototyping

Bristol Hartlage
Heather Dimeler; Courtney Sellers
Jennifer Whitton; Paxton Crick
April Jacks
John Hill
Miles Owen
Marielle Rufin; Alexandre Martin
Gary Campbell; Ernest Smith; Matt Feeny

Submitted By:

[X-Caliber]

March 11, 2004

Submitted To:

Dr. Robert A. Frederick
Associate Professor

Department of Mechanical and Aerospace Engineering
University of Alabama in Huntsville

frederic@eng.uah.edu

Class Web Page: <http://www.eb.uah.edu/ipt/>

Abstract

The main objective for Phase 2 was researching and considering as many options as possible. From this research, the group selected the three best concepts. After selection of the concepts, preliminary analysis of all three was performed and the results were “scored” based on compatibility with the Concept Description Document (CDD). The top-scoring concept will move on to Phase 3 for improvements and thorough analysis.

Resumé

L’objectif principal de la phase 2 est de rechercher et considérer le plus d’options possibles. A l’issue de cette recherche, le groupe sélectionnera les 3 meilleurs concepts. Après avoir sélectionné ces concepts, leurs analyses préliminaires seront réalisées et les résultats seront compatibles avec le CDD. Le concept “top-scoring” sera repris lors de la phase 3 pour des améliorations et une analyse profonde.

Technical Description

1.0 Overview of Phase 2

For Phase 2, the individual IPTs have worked independently to produce three alternative configurations to the Baseline. The deliverables for Phase 2 are a White Paper and a Poster Presentation. The White Paper compares the Baseline Concept¹ with three alternative concepts. The White Paper summarizes mathematical models and provides a technical rationale for selecting one concept from among the four presented.

The Project Offices of all four teams established a limited number of common guidelines for the Phase 2 Study. This provides some consistency among the teams in the scope of the Phase 2 studies. Guidelines limit the scope of the study to subsets of the conditions specified in the Concept Description Document. Assumptions state as true, something that is not true or not verified, for purposes of initial evaluations.

Table 1 – Common Guidelines for Phase 2 Study

Guideline	Reason
240 mm Threat Diameter	Baseline Threat Specification
500 m/s Threat Horizontal Velocity	Baseline Threat Specification
Head-on Engagement	Baseline Threat Specification
<u>Intercept 1</u> : 4 km Range; 1000 m Altitude	Objective Maximum Range Requirement; Maximum Altitude Requirement
<u>Intercept 2</u> : 2 km Range; 500 m Altitude	Threshold Maximum Range Requirement; Intermediate Altitude Requirement
<u>Intercept 3</u> : 500 km Range; 100 m Altitude	Threshold Minimum Range Requirement; Minimum Altitude Requirement
(+/-) 1 deg. Launcher Elevation Error	Evaluate Guidance
(+/-) 1.5% Muzzle Velocity Variation	Evaluate Guidance
0 m/s Crosswinds, Standard Day	Simplification and Consistency
Assumptions	
Hit-to-Kill is Volumetric Intersection of Threat and Projectile	Evaluate Guidance
Volumetric Intersection is a closest approach distance of no more that 140 mm	The distance between the centerline of a 240 mm rocket and a 40 mm round.

1.1 Specification Summary

The customer requirements are outlined in the CDD, which establishes the performance, interface, and environmental requirements for the Enhanced Counter Air Projectile (ECAP) weapons system. The ECAP shall achieve greater than 90% probability of hit for a moving target (up to 1800 km/hr) in wind conditions of 65 km/hr and gusts up to 83 km/hr at an effective range of 500 to 2000 meters. The maximum objective is 4000 meters. The ECAP shall be designed to interface physically, functionally, and operationally with an existing gun system. The dimensions of the ECAP shall be 40 mm in diameter and consistent with the chosen gun system. Furthermore, the ECAP must also be designed to eliminate safety and health hazards during both storage and operation.

1.2 Team 4 Approach to Phase 2

Baseline challenges being addressed are non-maneuvering targets, a lack of wind and gust models the fact that it does not take into account rotational velocity, and simulation with 6 Degrees of Freedom (DOF).

The majority of this simulation and modeling was conducted using a simple programming language. There are many advantages to using a programming language to develop source code to represent the models and ultimately the system simulation. Such advantages include cost, speed of execution, integration of models, verification and validation, and portability. Most simulations are not adequate, however, because an autopilot, guidance, and navigation routines are required for launch. The 3-DOF simulation only requires range, altitude, and flight path angle. The 6-DOF simulation requires the complete aerodynamic table (typically 6 coefficients) and more detailed mass properties. It also requires information regarding the autopilot, guidance, and navigation algorithms unless the concept is unguided.

Table 2 shows options available for the major design components. Included are seven main elements: Gun Platform, Acquisition Sensor, Projectile, Shell, Projectile Rotational Velocity, Guidance Concepts, Homing, Homing Sensors, Actuators & Controls, Computer & Electronics, Power, and Warhead. Each element has possible attributes that can contribute to the concept with major design requirements needed for its selection. The "Gun Platform" attributes include single barrel, multiple barrels, and multiple platforms. For "Acquisition Sensors" the attributes are (band) radar, (wavelength) infrared, and multiple sensors. Selections for the "Projectile" category include less than 40mm, greater than 40mm, equal to 40mm. The "Shell" category has possible attributes of only casting and non-casting. "Projectile Rotational Velocity" is separated into gun-spun, de-spun, and nonspinning. "Guidance Concepts" have possible attributes of none, command guidance, beam rider, and homing. "Homing" attributes include passive, semi-active, and active. "Homing Sensors" include radar, LADAR, infrared, visible, and multi-mode. "Actuators & Controls" selections include spoilers, thrusters, bent nose, lifting surface, body flap, flow control. "Computer & Electronics" options are ground based, onboard, or both. The "Power" category includes thermal batteries, DC motors, and capacitors. "Warhead" selections include hit to kill, fragment, electronic, and optical.

Table 2 - BOOST Selection Matrix

DESIGN ELEMENT	Possible Attributes						DESIGN REQUIREMENTS	
Gun Platform	Single barrel	Multiple barrels	Multiple Platforms	Other			Utilize smallest existing gun	
Acquisition Sensor	Radar (band)	Infrared (wavelength)	Multiple Sensors	Other			Maximize detection range	
Projectile	< 40mm	40mm	> 40mm	Other			Utilize existing projectile	
Shell	Casing	No Casing	Other				Utilize existing projectile	
Projectile Rotational Velocity	None	Gun-spun	De-spun	Non-spinning	Other			
Guidance Concepts	None	Command Guidance	Beam Rider	Homing	Other		Accuracy for lethality, Cost	
Homing	Passive	Semi-Active	Active	Other			Accuracy for lethality, Cost	
Homing Sensors	Radar	LADAR	Infrared	Visible	Multi-Mode	Other		Accuracy for lethality
Actuators & Controls	Spoilers	Thrusters	Bent Nose	Lifting Surface	Body Flap	Flow Control	Flared Aft Section --	
Computer & Electronics	Ground Based	Onboard	Both	Other			--	
Power	Thermal Batteries	DC generator	Capacitors	Other			--	
Warhead	Hit to Kill	Fragment	Electronic	Optical				

2.0 Alternative Concepts

2.1 Concept Synthesis

There are several key challenges that have arisen during the development of the IPT guided bullet. The most important aspect of the design involves whether to use a spinning or a non-spinning round. A spinning round may not require the use of a Sabot, however, it is assumed that a spinning round will not be as stable when turning. Controlling a spinning round is also more complicated due to the oscillatory nature of the controlling mechanisms. The bullet would also have to be powered on before launch for proper orientation. A non-spinning round would require the use of a Sabot, but could have a relatively fast reaction time and would be more stable in all positions. The non-spinning round would not have to be powered on before launch due to an onboard earth gravity sensor. The secondary issues (such as navigational techniques, system modeling, and power sources) are also important concerns that are strongly influencing the design.

The three primary designs that are being researched are spinning rounds with rocket motors around the CG and a sabot, non-spinning flared rounds with a sabot, and spinning, gyroscopically controlled rounds. The rocket motor rounds would require fast, intricate circuitry, several firing mechanisms, and would need to be powered on before flight. The non-spinning rounds would require the use of a sabot, but do not require fast circuitry or fast motor response (compared with a spinning round), and they are expected to have fast reaction times during turns. The gyroscopically controlled rounds would require the use of a battery, electromagnets, and a stable, non-spinning platform for the gyro to remain level. The gyro would be air driven and electromagnetically charged so that it can be controlled by external electromagnets. The major issue with this design is the ability to predict aerodynamic performance.

Table 3 - Alternative Concept BOOST Attributes

	Alternative Concepts			
	BL	4A	4B	4C
DESIGN ELEMENT	Bent Nose	ZF-1	Reverse Baseline	Electric Fire
Gun Platform	MK44	Bofors	Bofors	MK44
Acquisition Sensor	Microwave Radar	Microwave Radar	Microwave Radar	Microwave Radar
Projectile	40mm	40mm	40mm	40mm
Shell	No Casing	No Casing	No Casing	No Casing
Projectile Rotational Velocity	40 Hz	40 Hz	40 Hz	40 Hz
Guidance Concepts	Homing	Homing	Homing	Homing
Homing Configurations	Semi-active	Semi-active	Semi-active	Semi-active
Homing Sensors	Radar	Radar	Radar	Radar
Actuators & Controls	Bent Nose	Solid Thrusters	Flared Aft Section	Gyroscope
Computer & Electronics	On Board	On Board	On Board	On Board
Power	Thermal Battery	Thermal Battery, DC Generator	Thermal Battery	Thermal Battery, DC Generator
Structures & Packaging	NA	NA	NA	NA
Warhead	Hit to Kill	Hit to Kill	Hit to Kill	Hit to Kill

² <http://www.globalsecurity.org/military/library/news/2003/02/mil-030219-navsea01.htm>

³ <http://www.atk.com/productsPrecision/descriptions/products/GunSys/mk44.htm>

⁴ <http://www.quarry.nildram.co.uk/Bofors.htm>

2.2 Baseline Concept “Bent Nose”

The Baseline Concept was based on customer requirements. These requirements were listed in the CDD. The CDD defines the ECAP. The CDD is the “rule book” of the projectile design. Included are guidelines and assumptions about the baseline design that was previously constructed by the graduate students. In Figure 2 there is a breakdown of the baseline. The projectile has eight main areas of concern: Nose-control, Antenna, Signal Processor, Radar Computer, Guidance Computer, Lethality Enhancer, Safe and Arm, and Battery. The baseline has a diameter of 40mm, length of 259mm, and weights ~ 1.4kg. The Baseline was broken into five discipline areas and each discipline made recommendations for the design of the projectile. The areas include: Seekers and Guidance, Controls, Navigation and Power, Modeling and Simulation, and Launch Platform. The Seekers and Guidance recommended a guidance system with semi-active homing with proportional navigation. Semi-active homing was chosen because of the accuracy of a homing device and the reduction of onboard power of a semi-active homing device. Proportional Navigation was chosen as the best-suited navigation for semi-active homing guidance. The seeker system recommended was a millimeter wave (MMW) strap-down seeker. The MMW seeker provided all weather capability and worked well in strap-down mode. The Controls discipline recommended spinning bullet because the bullet would remain stable throughout the entire flight. Also, a bent nose was recommended because rate of spin in which the bullet was spinning. The Navigation and Power discipline recommended a thermal battery for the baseline design. A thermal battery was chosen because it had an acceptable shelf life, able to withstand harsh temperature and acceleration conditions, in ECAP size constraints, and was commonly used in missile applications. Controls required a huge range of voltages, which demanded larger batteries. The baseline was unable to supply enough power for all sub-systems. Power requirements for controls were excluded from the baseline design. Modeling and Simulation was done in the baseline design. Simulation of missile was launched at a non-maneuverable target. The simulation took into account atmosphere, aerodynamics, propulsion, mass properties, motion, and target. Simulations were done on cRocket code, which takes into account 3-DOF. Target inputs, projectile inputs, and intercept were placed in cRocket for simulations. cRocket was able to provide duplicate results for the baseline. However, there were problems with the simulations. Only 3 degrees of freedom were looked at. The simulation only took in to account non-maneuvering targets, no wind and gust, no propulsion model using thrust table, rotation of the bullet was not simulated. The Simulation discipline recommended that a more advanced simulation software (PRODAS) would be needed to provide a higher fidelity model of the missile and target. The Launch Platform discipline considered no gun system for the baseline design. A microwave radar system was selected for the baseline design and was assumed to be perfect. The baseline model was created, however it does not meet all of the CDD requirements. Problems that face to baseline model include the following: battery supply doesn't supply enough voltage, bent nose control design has the potential to interfere with the forward-mounted seeker, and length issues. Similarities between the baseline and the CDD are able to attain hit-to-kill ratio, 40mm diameter, seeker all-weather capabilities, has ability to kill baseline threat, bent-nose guidance system can operate within specified roll-rates, on atypical EM and/or radioactive emissions, and no chemical emissions.

2.3 Concept 4A “ZF-1”

The controls option for the ZF-1 is propulsion based, this is done by 8 to 12 small motors placed around the center of gravity of the shell as is shown in Figure 3. These motors would be a quick burning solid rocket fuel that would only burn for a few milliseconds. The ZF-1 would require fast circuitry to use these motors. The projectile would also require the use of an accelerometer to determine the orientation of the projectile while in flight.

The problems that need to be addressed in order to determine the feasibility of the ZF-1 include size restrictions for the rocket motors, if there are motors that deliver adequate impulse, and there is a possibility that the motor will not ignite.

The seekers and guidance option for the ZF-1 have not changed from the baseline. The ZF-1 will use a millimeter wave (MMW) strap-down seeker and a proportional navigation will be used for the guidance system.

The power supply is still being determined. The launch platform will be the Bofors L/70; this platform was chosen because it met the barrel size, and the maximum and minimum ranges

2.4 Concept 4B – “Reverse Baseline”

This bullet will use the specified guidance and controlled system. The bullet will be made from steel with a casing from the tail end to the nose. This bullet is more accurate on its target because it is more easily directed in flight. Unlike other options this does not use fins or spoilers. It carries a low-performance motor, which does not have to be powered before launch. The circuitry in the bullet will be less intricate than that of the spinning bullet. The motor used inside this bullet is low on power intake (power required), when compared with a spinning bullet. This bullet will be launch from a MK44, which uses a 40mm bullet. The projectile altitude of this bullet is between 100 – 1000m which meets the CDD requirement. The bullet will be belt fed to the MK44 for launch so that the 0.2 seconds response time can be met as required in the baseline assumption. One of the most important requirements for this project is accuracy. When comparing a spinning bullet to the non-spinning bullet there is one major advantage the non-spinning bullet has over the spinning bullet. That is the ability to change direction in flight in a predictable manner and lower control surface moments required to change angle of attack. The response time to change the trajectory is less than that of a spinning bullet, which increases the accuracy of the bullet. Therefore the non-spinning bullet is superior to the spinning bullet because of its aerodynamic performance.

On the major question, does his non-spinning bullet meet the requirements of the CDD, Let start with the requirements that the non-spinning bullet has in common, with the CDD. The range of the non-spinning bullet launched from a MK44 (gun system) is 1500m, which is the maximum range of the CDD. To launch this bullet from the MK44 (gun system) a modification will be done on the barrel of the gun. The power supply (battery) is low and does not require the amount of power mentioned in the CDD. Dimension of the bullet are as follows; diameter 40mm, length 259mm and weight ~ 1.4 kg. All the dimensions are CDD compliant, which meets the baseline design requirement. The seeker that the non-spinning bullet will use is a millimeter microwave system (MMW). This system (MMW) is capable of operating in different weather and altitude, which is specified by CDD.

The main problem that the non-spinning bullet presents is, as the name mention non-spinning bullet. The CDD requires that the bullet is compatible with a current gun system. Provided such a system can be obtained this is a feasible concept. The M256 gun of the M1A1 Abrams tank launches 120mm non-spinning rounds; therefore firing non-spinning rounds from a gun platform is possible. As mentioned above the reason for choosing this concept was based on the merit of accuracy and change of direction in-flight. The simulation of this was not available at this time which is done by a program call PRODAS, which will give the actual functionality description of the bullet in-flight.

2.5 Concept 4C – “Electric Fire”

Concept 4C utilizes an electromagnet and gyro as the mechanism for turning the guided bullet. As current is passed through the electromagnet the gyro will move in that direction, causing the bullet to turn. The gyro will sit on a platform held by bearings so that the gyro will not spin with the bullet. This configuration will require the bullet to use a beam rider for guidance. A battery will be used to provide sufficient current. The bullet will not be jacketed.

The five discipline areas are: Seekers and Guidance, Controls, Navigation and Power, Modeling and Simulation, and Launch Platform. The Seekers and Guidance recommended a beam-rider for the guidance system. A beam-rider is recommended for accuracy and the reduction of onboard power. The seeker system recommended was a microwave seeker. The Navigation and Power discipline recommended a thermal battery. A thermal battery was chosen because it had an acceptable shelf life, able to withstand harsh temperature and acceleration conditions, it was within ECAP size constraints, and was commonly used in missile applications. The Launch Platform discipline is considering the gun system MK 44.

Some concerns with this design are the size constraints of the electromagnet and gyro. It is unknown if an electromagnet and gyro could be found to fit within the bullet. The pitot tube will need to be designed so that the tube can provide an appropriate velocity of air while spinning with the bullet. Since the gyro is not spinning the tube must be able to swivel. The tube cannot open from the nose since the seeker will be present in the nose. The tube will have to open from the sides of the bullet. The battery will need to provide enough current and fit into the bullet. The team's knowledge of gyroscopes is limited. The Controls discipline is considering a non-spinning bullet because the gyro could cause the bullet to have an erratic flight, it may not be able to turn the bullet as long as it is spinning. The gun system has a range that will allow the bullet to reach ranges of two kilometers, but not the preferred four kilometers. Modeling and Simulation will have a difficult time analyzing the movement of the gyro and relating it to the movement of the bullet. Similarities between the Electric Fire and the CDD are able to attain hit/kill ratio, the 40mm diameter, it has ability to kill the threat, and it has no chemical or radioactive emissions.

This design may be used to provide power for another system. Solenoids would be fixed to the bullet, spinning at 40 Hz and surrounding a small magnet. The magnet would be surrounded by a damping material, which would cause it to spin slower than the solenoids, producing an alternating current within the solenoids. This current could be used to provide additional power to the system.

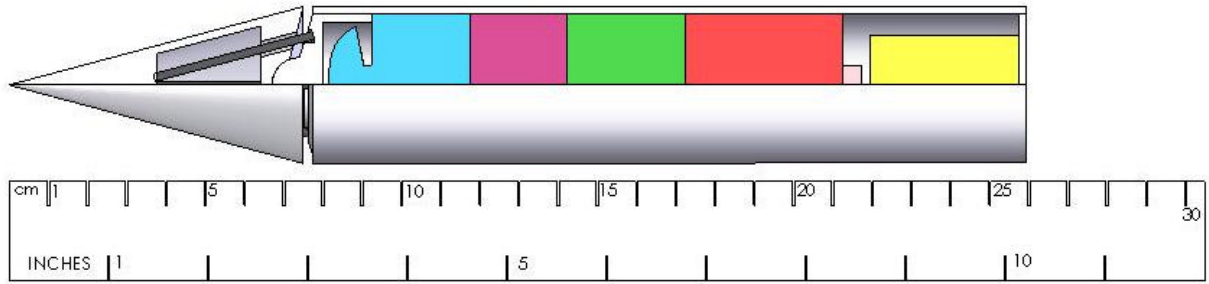


Figure 2. Baseline "Crooked Arrow"

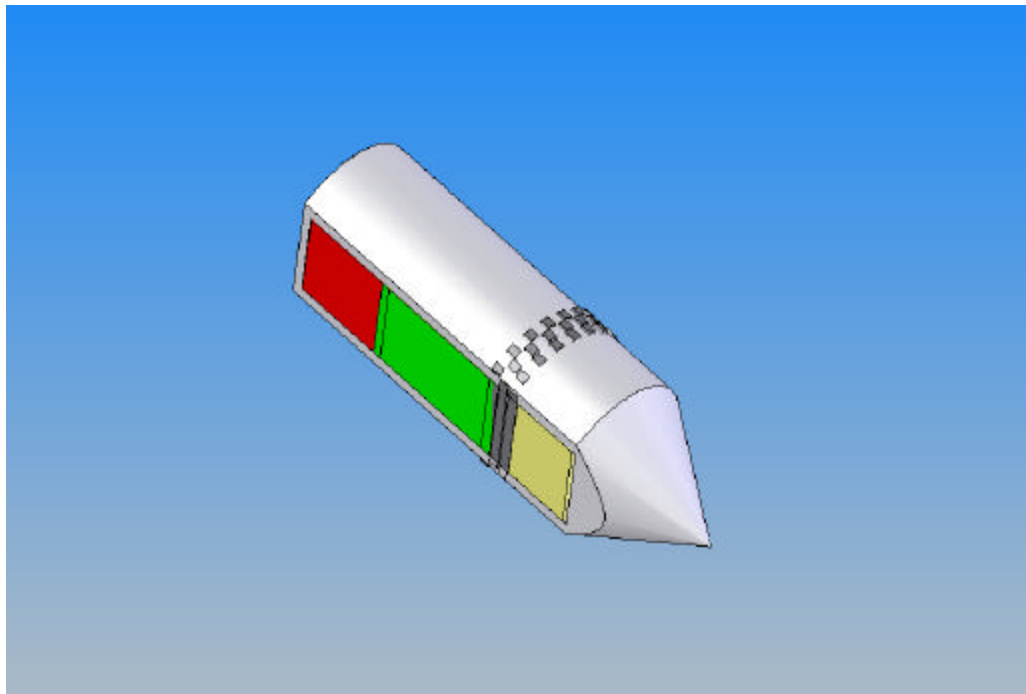


Figure 3. Concept 4A "ZF-1"

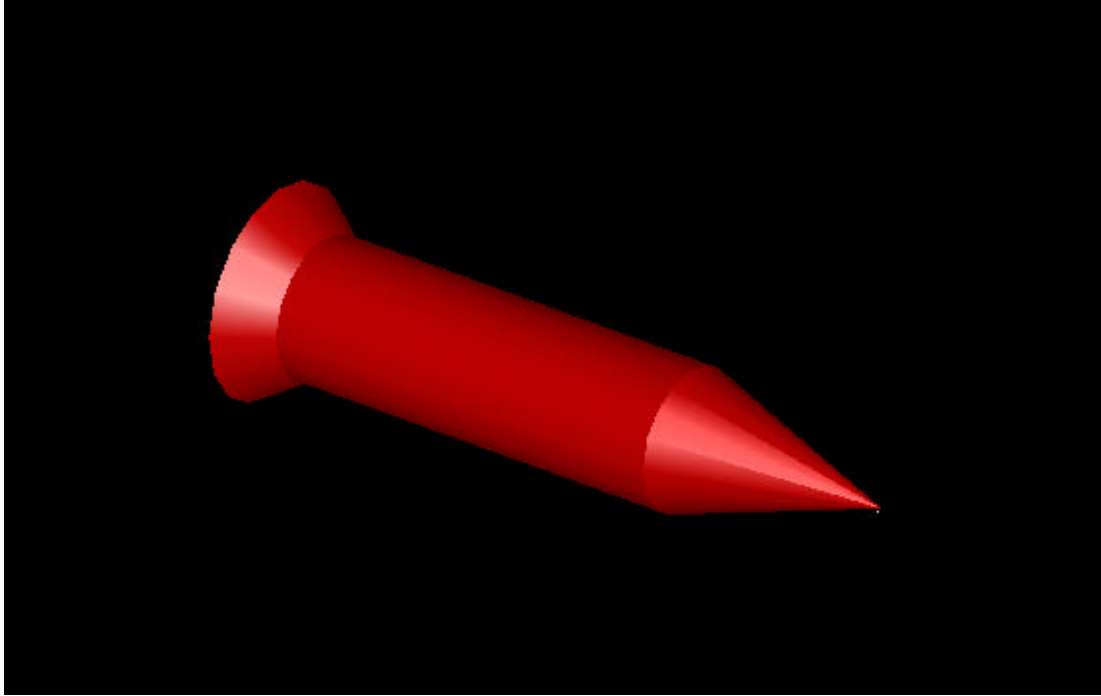


Figure 4. Concept 4B "Reverse Baseline"

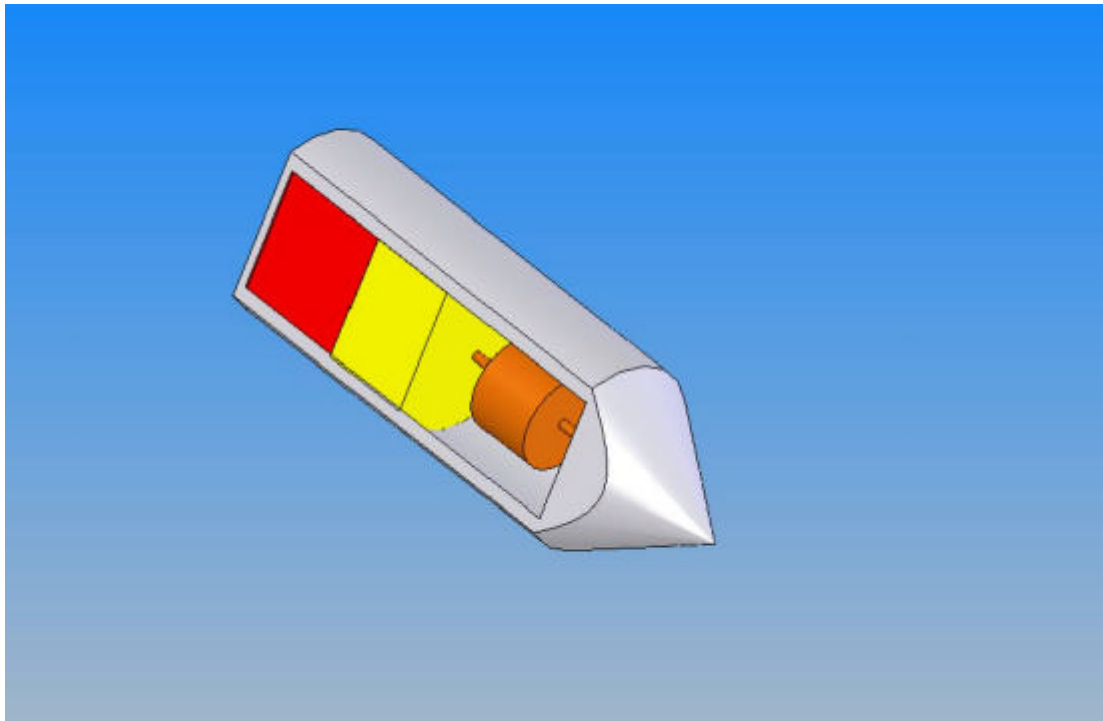


Figure 5. Concept 4C "Electric Fire"

Table 4 - First Order Engineering Data Table

Parameter	Units	Baseline	4A	4B	4C
Projectile Data		Bent Nose	ZF-1	Reverse Baseline	Electric Fire
Projectile Diameter	mm	40	40	40	40
Projectile Length	mm	260	260	260	260
Projectile Mass	kg	1.38	1.38	1.38	1.38
Muzzle Velocity	m/s	1100	1100	1100	1100
Proportional Navigation Constant		4.0	4.0	4.0	4.0
Maximum Acceleration, x	m/s ²	0.0	0.0	0.0	0.0
Maximum Acceleration, y	m/s ²	37.5	37.5	37.5	37.5
Maximum Acceleration, z	m/s ²	37.5	37.5	37.5	37.5
Drag	T/F	0	0	0	0
Battery Power Time	sec	0.01	0.01	0.01	0.01
4-kM, Intercept Target Altitude, 1000 m					
Launcher Elevation Angle	deg	7	7	7	7
Launcher Elevation Error	deg	0	0	0	0
Shot Path	m	4123	4123	4123	4123
Time of Flight	sec	3.48	3.48	3.48	3.48
Closest Approach	m	0	0	0	0
Closing Velocity	m/s	955	955	955	955
2-kM, Intercept Target Altitude, 500 m					
Launcher Elevation Angle	deg	7	7	7	7
Launcher Elevation Error	deg	0	0	0	0
Shot Path	m	2061	2061	2061	2061
Time of Flight	sec	1.754	1.754	1.754	1.754
Closest Approach	m	0	0	0	0
Closing Velocity	m/s	954	954	954	954
0.5-kM, Intercept Target Altitude, 100 m					
Launcher Elevation Angle	deg	7	7	7	7
Launcher Elevation Error	deg	0	0	0	0
Shot Path	m	509	509	509	509
Time of Flight	sec	1.034	1.034	1.034	1.034
Closest Approach	m	0	0	0	0

IPT 4**Competition Sensitive until May 1, 2001**

Closing Velocity	m/s	400	400	400	400
------------------	-----	-----	-----	-----	-----

3.0 Selection of Final Concept

Table 5 is the ECAP concept selection matrix. The matrix compares the baseline concept along with three group-selected concepts. The group utilizes the matrix to “grade” the concepts based on their compatibility with the CDD requirements. Each category of the matrix was given a number value from zero to ten corresponding to the compatibility with the requirement, i.e. the higher the value the higher the compatibility. If the concept was in no way compatible it was given a zero, if it was possibly compatible it was given a score of five, and if it was definitely compatible the concept was given a ten. If the concept had not been evaluated in a certain area it was given a “grade-less” NE. This point system was used for every category in the matrix and the score was totaled. The highest score was deemed to be the most compatible and would determine the final concept that would be chosen.

Along with the existing categories of the matrix two user-defined categories were also included. These categories are assessability, measuring the difficulty of assessing each concept based on the knowledge that the group possesses; and Computer Simulation Ability, measuring the difficulty of simulating the flight of each concept.

The results from the ECAP matrix proved that the non-spinning round concept is the most compatible with the CDD requirements since it had the highest score.

Table 5 - ECAP Concept Selection Matrix against a Baseline Threat

Compliance Legend

NE -Not Evaluated	No [0]	Maybe [5]	Yes [10]
-------------------	--------	-----------	----------

			4B: Reverse Baseline	4C: Electric Fire	
Maximum Range of Threat	4 km	4km	4km	1.5km	2 km Threshold; 4 km Objective;
Minimum Range of Threat	NA	0.5km	0.5km	0.5km	0.5 kM
Altitude of Threat	500m	1000m	1000m	1000m	100 m to 1000 m
Projectile Dia.	40 mm	40mm	40mm	40mm	40 mm
90 % Probability of kill Accuracy	NE	NE	NE	NE	15 Shots Threshold; 10 Shots Objective
Total Targets	1	12	12	12	12 Targets; 4 s. Int
Closest Approach	0 mm	0mm	0mm	0mm	Hit-to-Kill (140 mm)
Crosswind	NE	NE	NE	NE	65 km/hr sustained; 83 km/hr gust
Gun System	MK44	Bofors	Bofors	MK44	MK 44 or Bofors
Environmental	NE	NE	NE	NE	Military Environments
Storage/ Trans.	NE	NE	NE	NE	Military Environments
Reliability/ Safety	NE	NE	NE	NE	Military Environments
OTHER					
Cost	Med	Med	Low	High	Low, Med, High
Manufacturability	NE	NE	NE	NE	Threshold: Reported Objective Demonstrated
Tech. Maturity	Batteries	Value	Value	Value	Threshold: Reported Objective C.O.T.S.
Assessability of Concepts	NE	10	10	5	Ability to assess concept with current knowledge
Computer Simulation Ability	NE	5	5	0	Ability to simulate concept on PRODAS
Total Score	55	100	105	80	Normalized to 110

4.0 Phase 3 Plan

4.1 Phase 3 Issues

The major issues that must be addressed in order to deploy the concept by the required date are the performance and functional requirements. The concept needs a maximum range of 4000m, and have the ability to withstand winds up to 65km/hr and gusts up to 83km/hr. The concept also must have a 90% probability of kill with a round burst of 10-15 of the baseline target, which is a 240mm rocket 100-1000m high traveling at a speed of 500m/sec. The preferred requirements for the concept of 40mm round that can interface seamlessly with current launch systems, and meet all current storage and shelf life requirements. Old technologies, for example the concept of a non-spinning bullet, have been recognized, but have only been researched slightly. New technology that can, or will, be developed in order to deploy the concept by the required date have been considered, but have not been accepted due to the fact that they have not been researched in full detail to achieve concept's success. Examples being the use of spoilers, fins, magnets, and CG change in the controls section of the concept. In respect to the interfaces with the station it has been agreed upon that the Bofors L70 and MK44 are the two major launch platforms in consideration for the concept. Testing has not yet been achieved due to the fact that there will be a new simulation program for the concept. PRODAS is a more superior simulation program that will take into account an increased and more detailed amount of variables when the concept is in flight. Funding is still yet unknown for the time being, but as told by the customer expenses for the concept is approximately \$100 per bullet concept.

¹ Landrum, D.B. and Frederick, Jr., R.A., "Guided Bullet Technology Primer," AIAA Tactical Missile Interceptor Symposium," January 16, 2004, Huntsville, AL.

4.2 Phase 3 Schedule

The first and second weeks of phase three consist of the first design iteration. This requires each discipline to obtain several solutions to their requirements. Using power as an example, the student will be required to have different batteries such as thermal impact-activated battery, thermal squib-activated battery, chemical battery, etc. The team will then perform the first iteration by incorporation one solution from each discipline into the bullet.

During weeks two through four the team will refine the first iteration. This is accomplished through assessing the limitations and requirements of the first iteration. Different configurations will be analyzed in order to find a suitable solution for the final design, which will be assessed during weeks four and five. Weeks five and six consist of the prototype manufacturing and final report compilation.

PRODAS will be the primary tool used to model the system. It will be supported by dynamic calculations to describe the response time of the system.

Table 6 – Phase 3 Schedule

Activity	Week 1	Week 2	Week 3 (Spring Break)	Week 4	Week 5	Week 6
First Design Iteration	X	X				
Concept Refinement		X	X	X		
Final Design Assessment				X	X	
Prototyping Manufacturing					X	X
Final Report Compilation					X	X

5.0 List of Symbols and Acronyms

Table 7 – List of Symbols and Acronyms

Symbol/Acronym	Units	Description
BOOST		Barbie Outfit Organizer Slider Thing™
BL		Baseline
CDD		Concept Description Document
ECAP		Enhanced Counter Air Projectile
IPT		Integrated Product Team
NE		Not Evaluated
UAH		The University of Alabama in Huntsville
ZF-1		Propulsion driven bullet concept (4A)

5.0 References

- 1) Landrum, D.B. and Frederick, Jr., R.A., "Guided Bullet Technology Primer," AIAA Tactical Missile Interceptor Symposium," January 16, 2004, Huntsville, AL.
- 2) <http://www.globalsecurity.org/military/library/news/2003/02/mil-030219-navsea01.htm>
- 3) <http://www.atk.com/productsPrecision/descriptions/products/GunSys/mk44.htm>
- 4) <http://www.quarry.nildram.co.uk/Bofors.htm>

¹ Landrum, D.B. and Frederick, Jr., R.A., "Guided Bullet Technology Primer," AIAA Tactical Missile Interceptor Symposium," January 16, 2004, Huntsville, AL.

² <http://www.globalsecurity.org/military/library/news/2003/02/mil-030219-navsea01.htm>

³ <http://www.atk.com/productsPrecision/descriptions/products/GunSys/mk44.htm>

⁴ <http://www.quarry.nildram.co.uk/Bofors.htm>

IPT X**Competition Sensitive until May 5, 2004**

Instructor Grading Guideline for Phase 2 White Paper

Categories	Points	Description	Excellent
Concept Synthesis		Do the attributes selected for each alternative logically fit together? Did the team examine a suitable breath of alternatives?	20
Technical Clarity and Credibility		Could the results be reproduced with the information provided? Are the required technical results reasonable and complete? Are unusual results recognized or highlighted?	20
Assessment Logic		Is the assessment method clearly explained? Is the assessment and selection method logical?	20
References		Are there numbered citations at the appropriate point in the text? Are the endnotes complete enough to be independently acquired?	20
Clarity of Explanations		Can the reader clearly understand the meaning of the paragraphs? Is the writing free of mechanical errors? (Spelling, grammar, etc.)	10
Format Compliance		Does the document present the information in the required format (order, style, page location, units)	10
Total			
Early Submissions		10% per hr up to 3 hrs	
Late Submission		10% per hour up to 10 hours.	
Plagiarism		(50% Deduction) "...use of any other person's work (such work need not be copyrighted) and the unacknowledged incorporation of that work offered in fulfillment of academic requirements. ¹	
Final Total			

¹ UAH Student Handbook 2002-2004, page 93.

IPT 4

Competition Sensitive until May 1, 2001

IPT 2004 Phase 2 - Review Team Feedback Form

Team X, Reviewer Y

Category				Description
Concept Synthesis	Superior	Adequate	Not Responsive	Do the attributes selected 1 Did the team examine a su
Technical Clarity and Credibility	Superior	Adequate	Not Responsive	Could the results be repro Are the required technical
Assessment Logic	Superior	Adequate	Not Responsive	Is the assessment method c Is the assessment and selec
Evidence of Teamwork	Superior	Adequate	Not Responsive	Are the ideals presented w Are the details of the docu
Potential Viability of Assessing Selected Concept	Superior	Adequate	Not Responsive	Are the technological level adequate phase 3 assessme
Overall Rating	Superior	Adequate	Not Responsive	Comments: