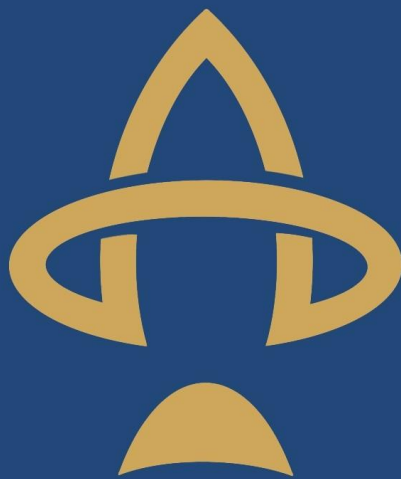




Rocket Mission Works



Apache Flare Effectiveness Study
V 1.0 – Oct 2023

Contents

1. Objective
2. Methodology
3. Background
4. Test setup
5. Results
6. Observations
7. Conclusions

1- Objective

Purpose

This study examined the performance of flares from the Eagle Dynamics AH-64D Apache against infrared (IR) surface-to-air missile (SAM) systems, to determine an optimal flare pattern.

Objectives

- Determine base decoy rate of single flare.
- Examine impact of flare quantity on decoy rate.
- Examine impact of burst intervals on decoy rate.
- Examine impact of salvo intervals on decoy rate.
- Determine optimal flare program.



Flare decoying a missile

2- Methodology

The focus of this study is the effectiveness of reactive flares against IR SAMs. IR SAM engagements are complex and can be impacted by aircraft aspect angle, aircraft range, throttle level, and environmental factors. These variables were kept as constant as possible to isolate flares as the determining factor in successfully decoying a threat missile.

For this test the aircraft flew a straight and level course at a constant speed in the same conditions. The only reaction to a missile launch was dispensing flares, and no maneuvers were incorporated. Multiple IR SAMs were deployed along the flight path to replicate a variety of engagements from multiple ranges and aspects.

Assumptions

- All missile shots are equal.
- Aspect angle does not impact missile tracking performance.
- Maneuvers would be included with flares in game.
- All IR missiles handle flares the same.
- The dispensing bucket does not impact decoy rate.

Terminology

Decoy: Missile broke track from aircraft to flare.

Dispense: A flare drop sequence.

Aspect Angle: Missiles perspective of aircraft.

3- Background

Apache Flare Profiles

The Apache can carry up to 60 flares, but the individual number can not be modified. Flares are programmed from within the Mission Editor, or on the kneeboard.

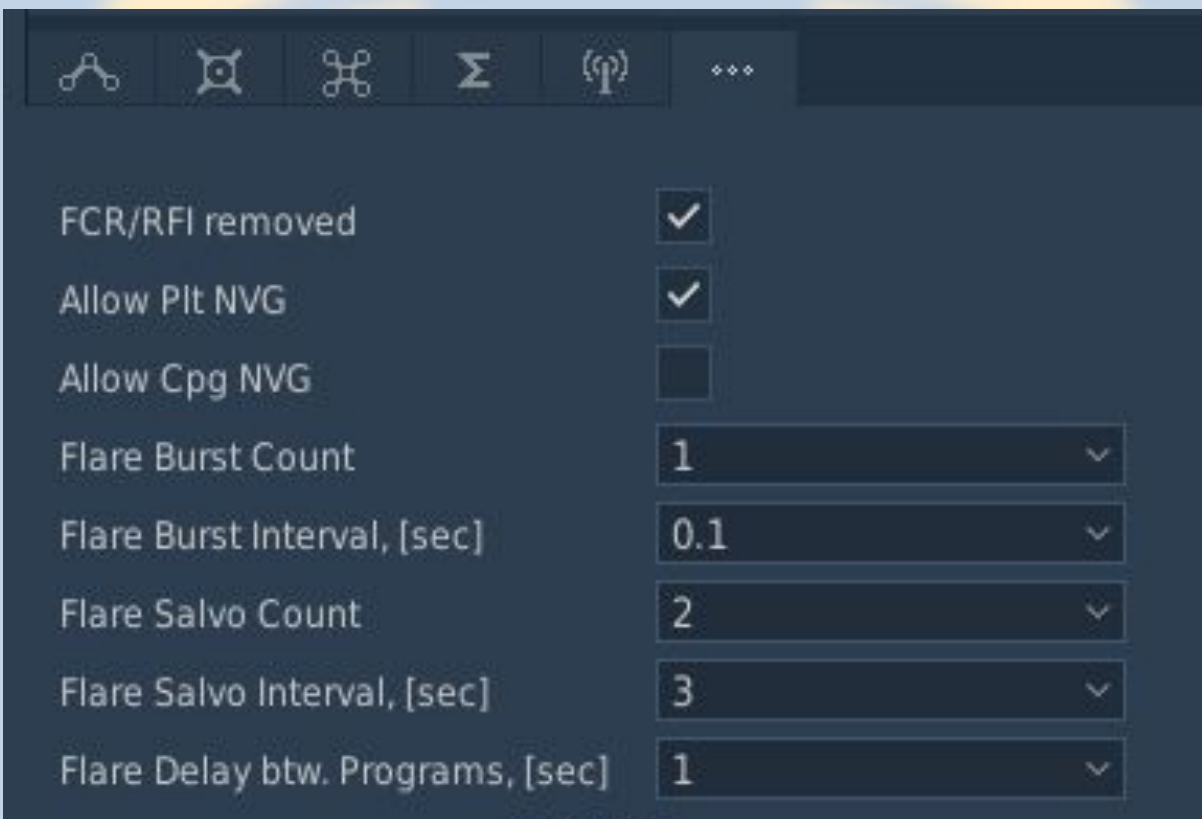
Flare Burst Count(#): Number of flares dropped per burst.

Flare Burst Interval: Time between flare drops within a burst, in secs.

Flare Salvo Count(#): Number of burst sequences per salvo.

Flare Salvo Interval: Time between bursts within a salvo, in secs.

Flare Delay btw Program: Delay between programmed scenario repeats, in secs.



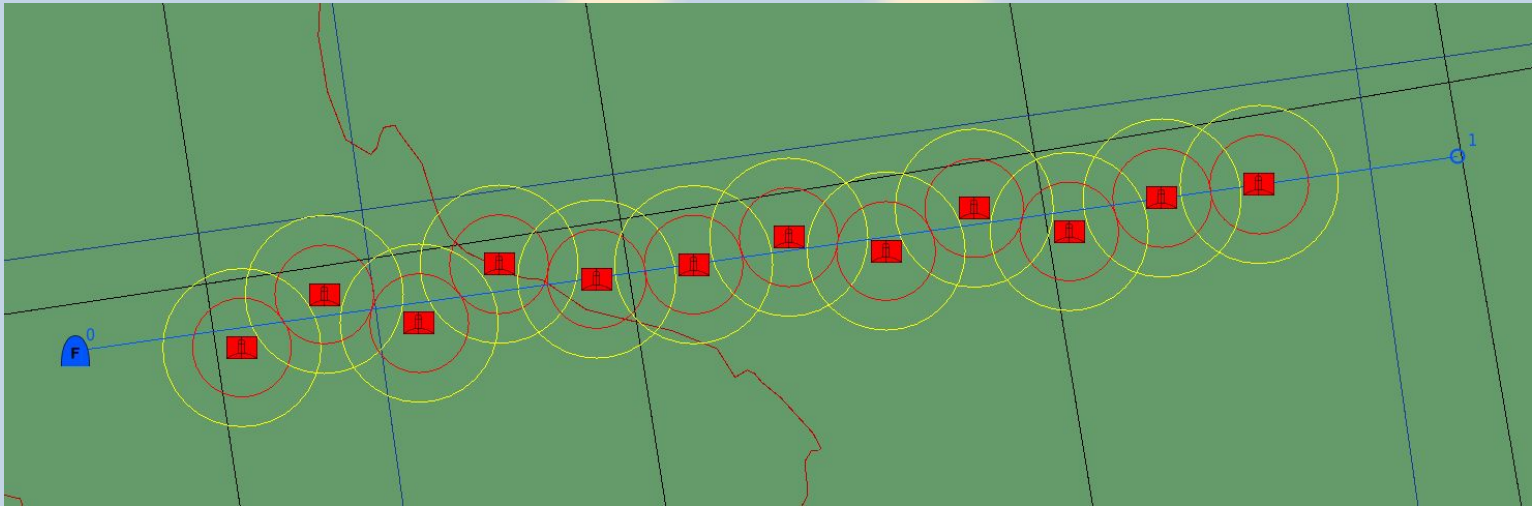
FCR/RFI removed	<input checked="" type="checkbox"/>
Allow PIt NVG	<input checked="" type="checkbox"/>
Allow Cpg NVG	<input type="checkbox"/>
Flare Burst Count	1
Flare Burst Interval, [sec]	0.1
Flare Salvo Count	2
Flare Salvo Interval, [sec]	3
Flare Delay btw. Programs, [sec]	1

Apache Flare Programmer in Mission Editor

4- Test Set-up

Test Setup

The test aircraft was flown along a straight path through the engagement zone of multiple IR SAMs. Flares were deployed once the missile had reached a steady guidance track on the aircraft.



Test flight path

Ten flare profiles were each tested against 100 engagements, with variable flares per cycle, cycle quantities, and cycle intervals.

Threat System	
SAM	SA-13
AI Level	Average
Time of Day	8 AM

Aircraft Parameters	
Aircraft Altitude	~1000 ft AGL
Aircraft Speed	~115 kts
RPM Setting	~84%

5- Results

Flare Program Results

Profile	Program (B #/B Int/S #/S Int)	Decoy Rate	Flares/ Decoy	Dispenses Possible	Average Defeats
1	1/0/1/N/A	50%	2	60	30
2	2/0.1/1/N/A	78%	3	30	20
3	3/0.1/1/N/A	90%	3	20	20
4	2/0.2/1/1	74%	3	30	20
5	2/0.3/1/N/A	85%	2	30	30
6	1/0.1/2/1	80%	3	30	20
7	1/0.1/2/2	75%	3	30	20
8	1/0.1/2/3	58%	3	30	20

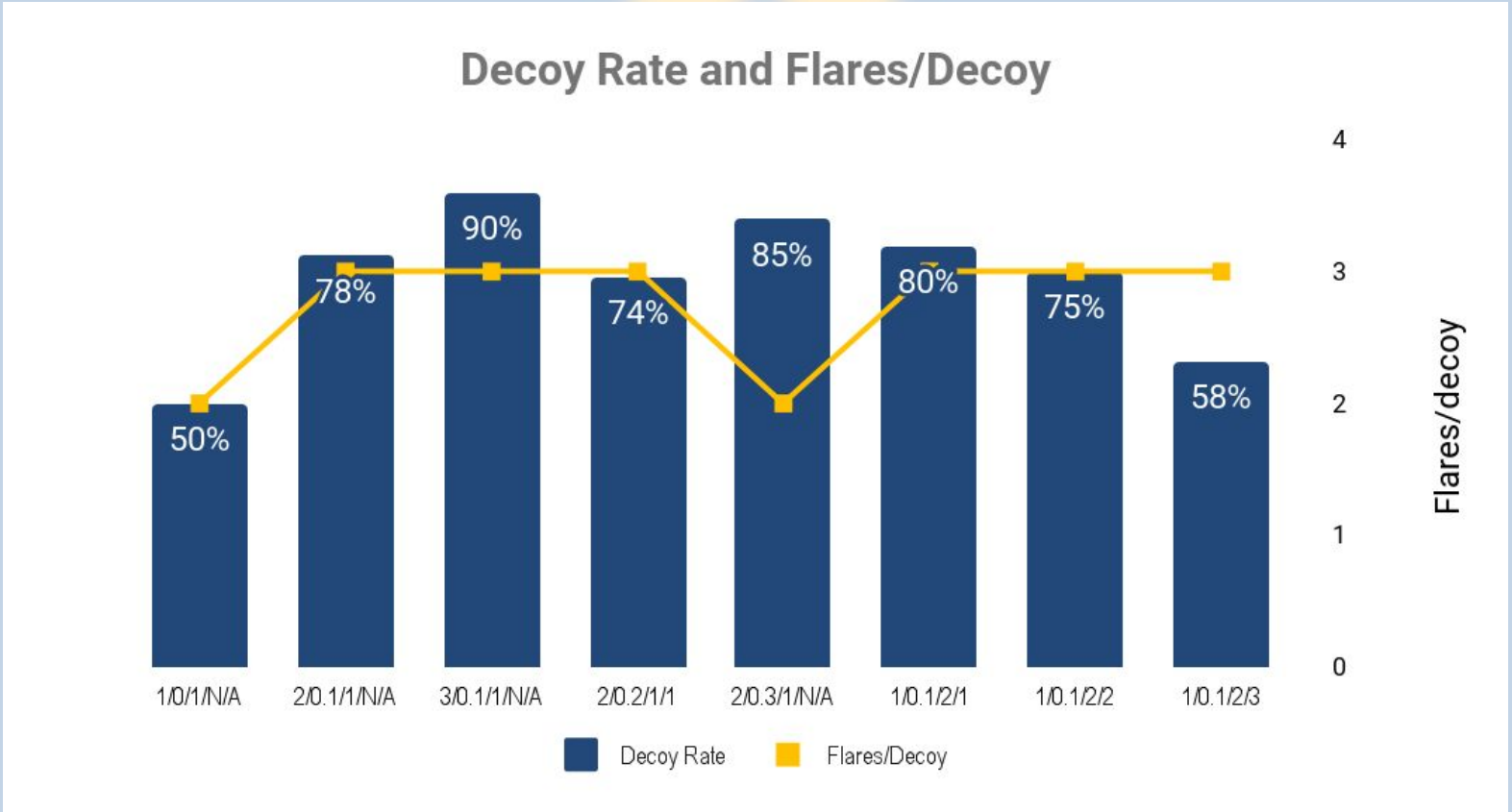
Decoy Rate: Percentage of missiles decoyed by flare profile.

Flares/Decoy: Average number of flares required to decoy a missile. A measure of profile efficiency.

Dispenses Possible: Maximum number of times the full profile can be run with 60 flares.

Average Defeats: Average number of missile defeats with default flare quantity.

5- Results



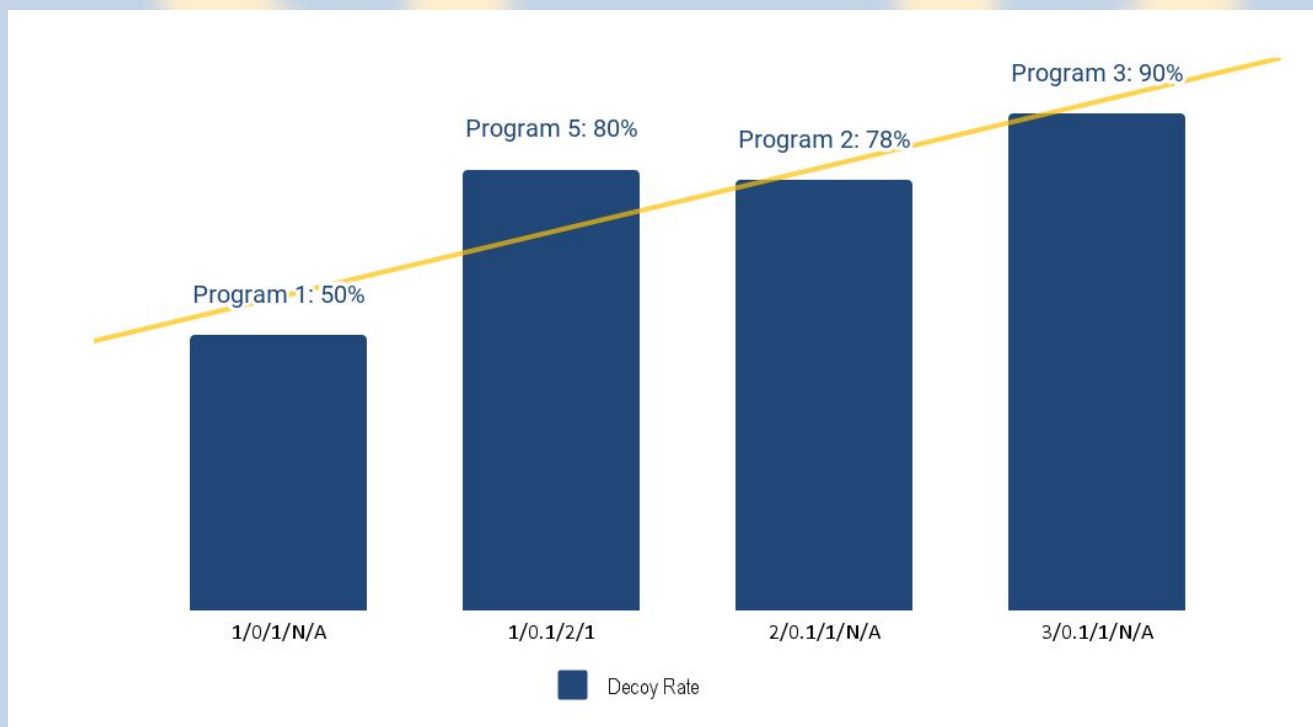
Decoy Rate: Percentage of missiles decoyed by flare profile.

Flares/Decoy: Average number of flares required to decoy a missile.
A measure of profile efficiency.

6- Observations

Impact of flare quantity on decoy rate: Programs 1, 2, 3, and 6 were the samples used to examine impact of flare quantity on decoy rate. Programs 1, 2, and 3 explored increasing the number of flares per burst, while program 6 explored having two salvos with one flare per burst.

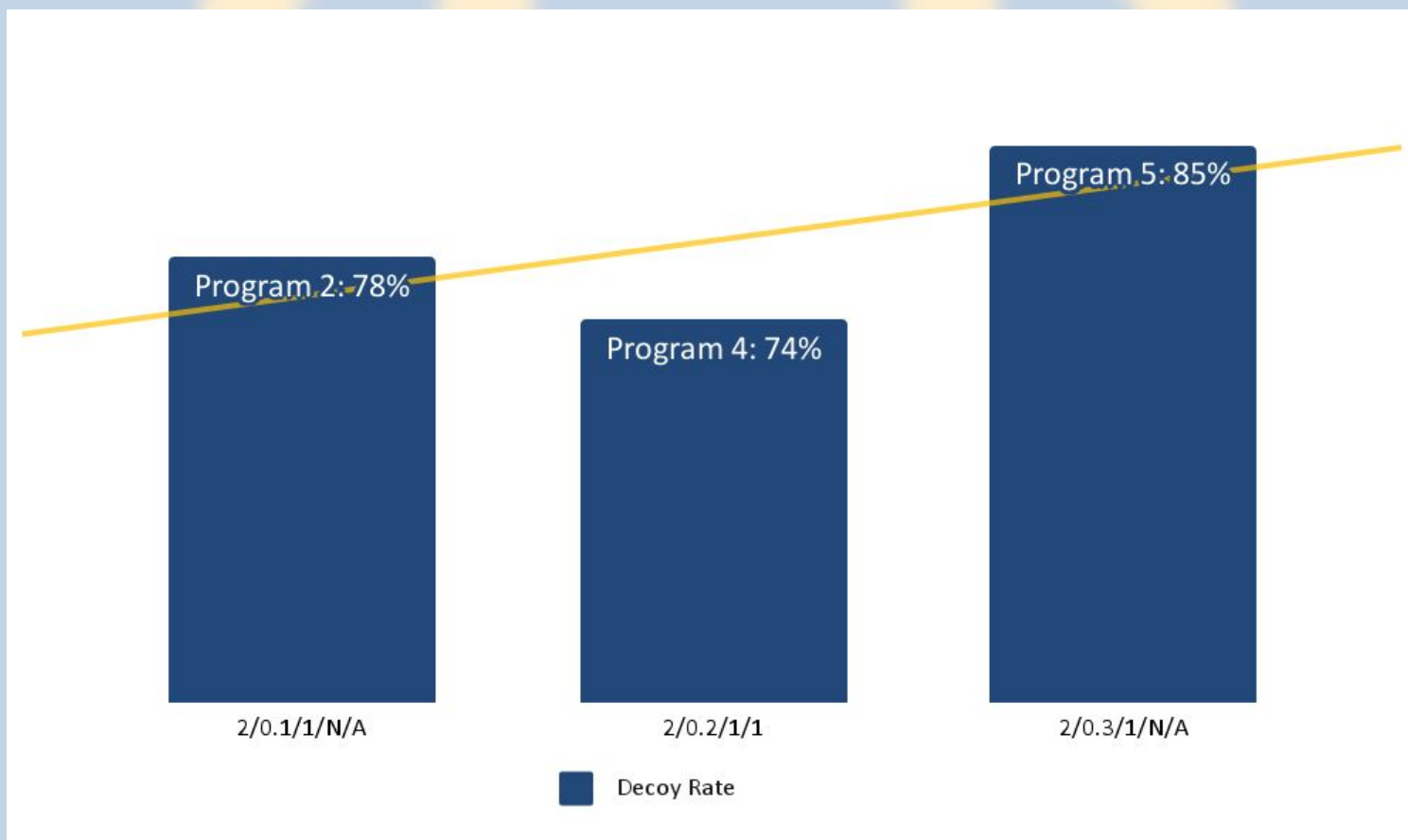
There is a definitive improvement in decoy rate with increased quantity of flares. However, the Apache has a high decoy rate per flare. Therefore, less flares are required to reach a satisfactory level of decoy success. The low number of flares required also means that most programs have a similar flare/decoy rate. Overall, while programs with higher flare dispenses have improved decoy rates they are not necessarily more efficient.



6- Observations

Impact of burst interval on decoy rate: Programs 2, 4, and 5 were the samples examined for burst interval impact on decoy rate. These samples had two flares total dropped in increments of two flares dropped per burst, one salvo per program, with burst interval times increasing.

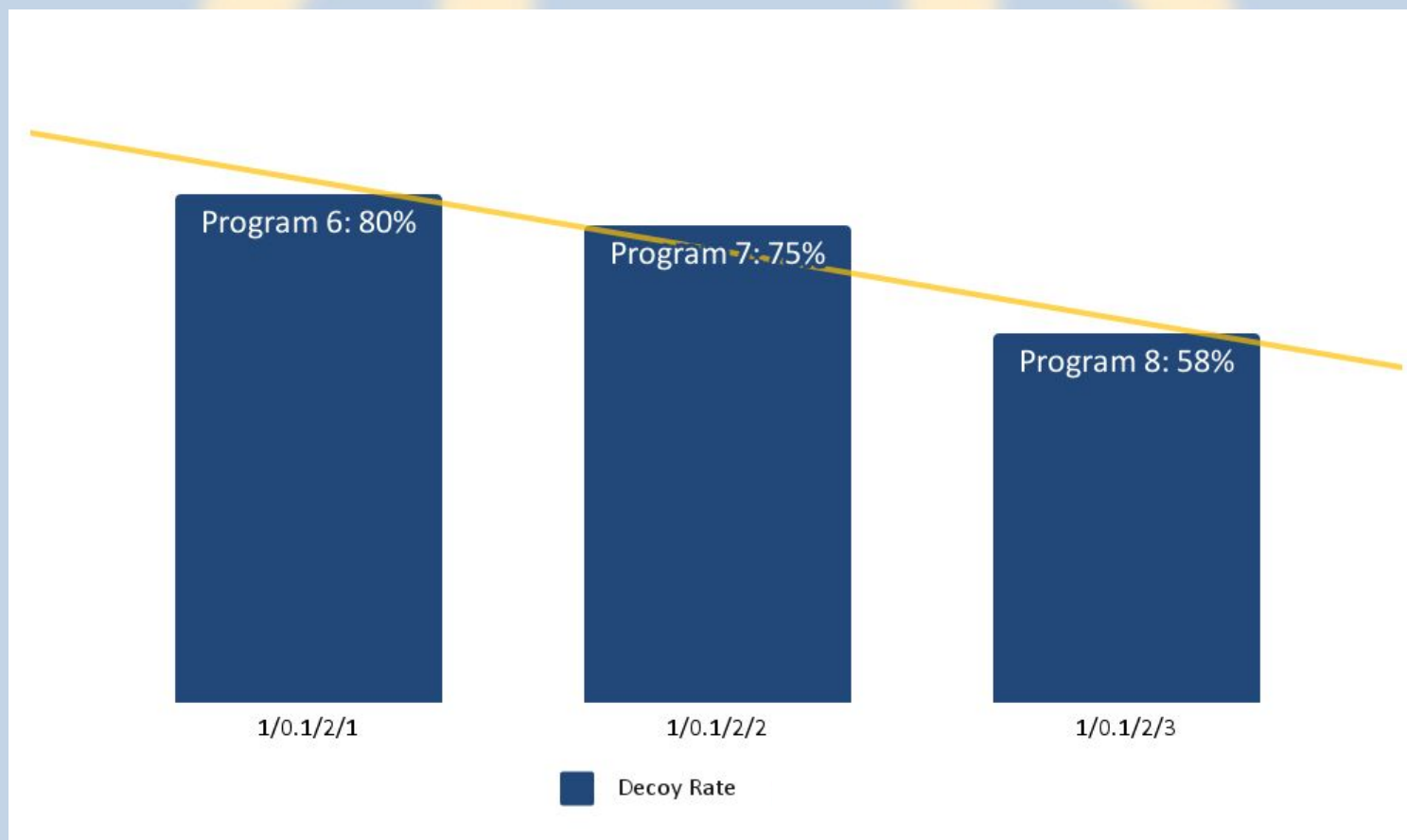
There is no clear association for burst interval improving decoy rate. Program 4 showed a lower decoy rate, while program 5 showed a higher decoy rate. There is no clear reason for this difference, but it is possible that these are statistical deviations. The relatively small burst interval increment (.1 sec) should not drastically change how the flares are presented to the missile. The trend is an improvement in decoy rate with increased burst interval.



6- Observations

Impact of salvo interval on decoy rate: Programs 6, 7, and 8 were the samples used to examine impact of salvo interval on decoy rate. These samples consisted of two total flares dropped in increment of one per burst with two salvos. Burst Intervals were kept constant.

There was a clear decrease in decoy rate based on salvo interval. The Apache has a large gap in interval spacing increments (1 sec), resulting in significantly longer program dispense times. At the longer salvo intervals this can result in missiles flying a significant distance between salvo dispenses. At shorter ranges this results in the missile reaching the aircraft before the program is complete, likely significantly reducing the decoy rate.



7- Conclusions

Optimal Profile Tested:

Burst #: 2
Burst Int: .3 Sec
Salvo #: 1
Salvo Int: N/A

Recommended profile Tested:

Burst #: 1
Burst Int: .1 Sec
Salvo #: 1
Salvo Int: N/A

Based on the testing there is a clear improvement in decoy rate with increased quantity of flares, as would be expected. The increased burst interval time has an unclear impact on decoy rate, while increased salvo interval time has a clear negative impact on decoy rate. The Apache overall has significantly better flares compared to other aircraft tested, with a base decoy rate of ~50% for a single flare. Due to this, there is not as much flexibility in flare programming to improve decoy rate.

Accordingly, the optimal profile tested involved a program with two flares per burst with a burst interval of .3 secs, dropped in only a single salvo. This provides the optimal mix of decoy rate and number of potential dispenses. However, due to the high decoy rate of the single flare, it is recommended that only one flare be used per burst. The decoy rate, while lower, is still significant and allows pilots more flexibility in how many flares they dispense to optimize retention of flares.

Several factors would likely improve the decoy rate against IR SAMs, though they were not tested in this study.

- Throttle chop prior to or while dispensing flares.
- Maneuvers while dispensing flares.
- Use of the sun to decoy missiles.