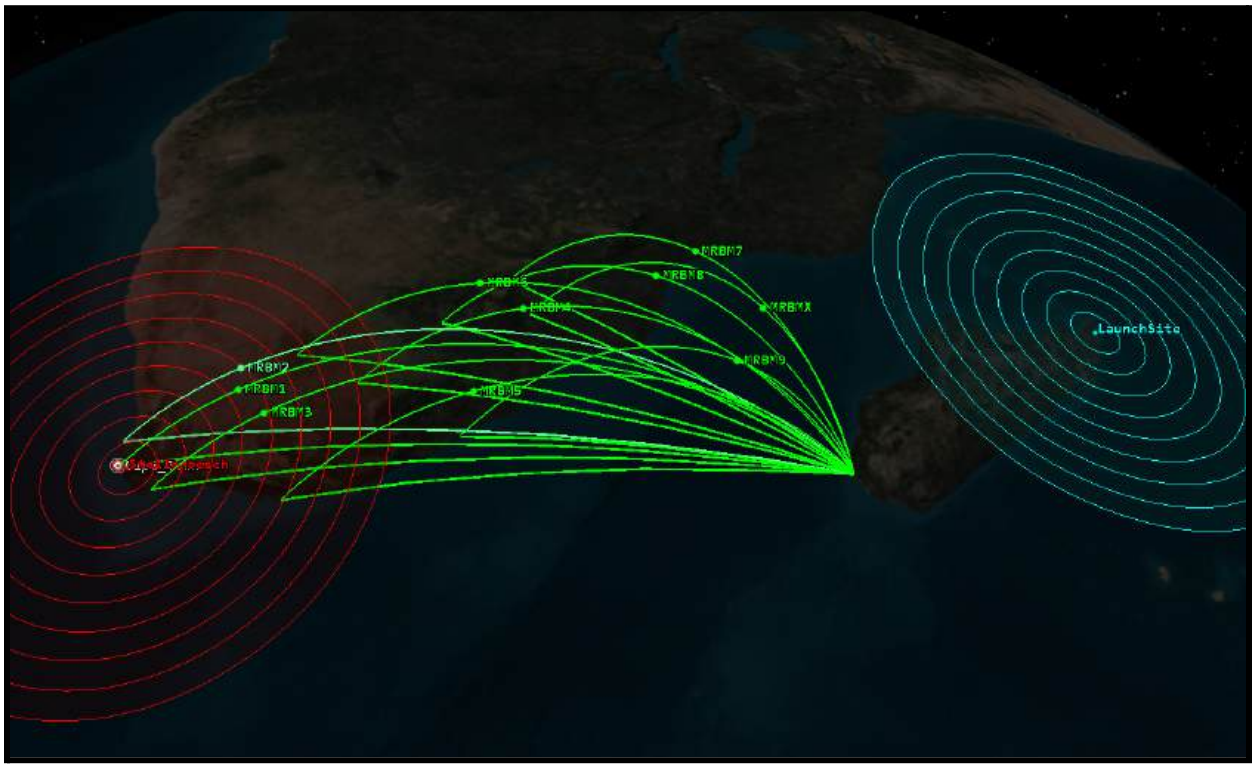
Project 2
Constellation Conflict
Offensive Proposal



By: Thomas J Todaro
Course: ME 456 Advanced Astrodynamics
Professor: Dr. Andrew Abraham
Due: 5/2/2025

Representing Madagascar

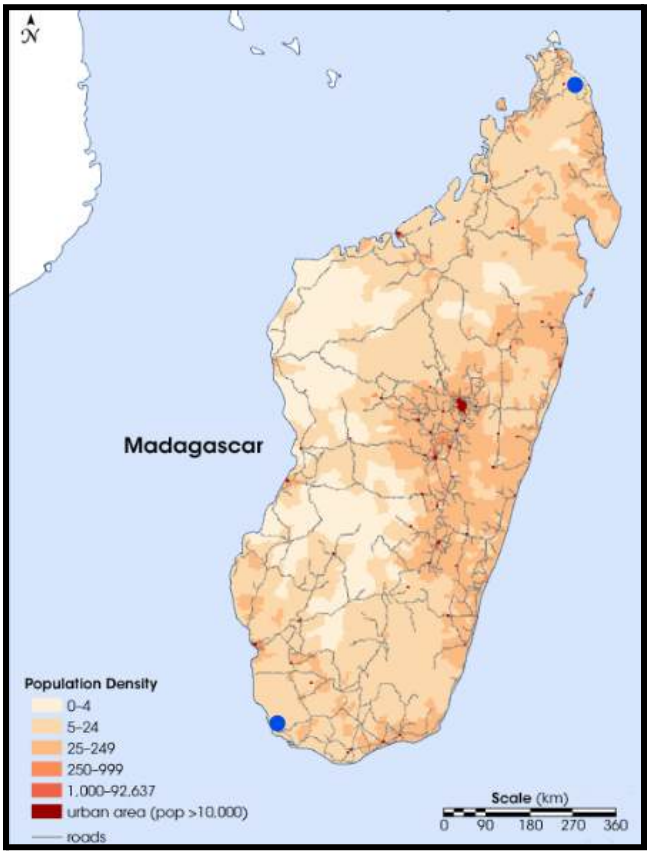
Table of Contents:

Abstract

As tensions continue to rise between the governments of Madagascar and South Africa due to threats of firebombing and disabling our wildfire detection satellite constellation with the intent of hindering our control of the damage, we are inclined to return in kind. As representatives of the Firebomb Defense Organization of the country of Madagascar, we present a solution to the incumbent threat that has developed between our nation and that of Southern Africa. This solution involves the degradation of South Africa's own satellite constellation designed to monitor and address incoming missiles, followed by a ballistic missile raid in retaliation to imminent fire bomb attacks.

Background

A recent data breach within South Africa has fortunately offered our team detailed simulations of the adversary's "Iron Dome" constellation. By utilizing this data and verifying it with our ground surveillance network, we have been able to detail a plan of attack. Our chosen launch location for the preparation ASAT mission lies at the coordinates -12.741752028292693, 49.54107239058446 which is on the North Eastern coast of the island. This location is of strategic advantage because it is the furthest from South Africa, generally unpopulated, and is just to the east of the Maromokotro mountains, providing further cover from retaliation or disruption.



Population Map of Madagascar, Launch Locations Highlighted in Blue

Based on the data we received and verified through our own tracking of overhead satellites, the adversarial system is a combination of a 150/15/1 LEO tracking constellation and an 8/4/1 MEO informant constellation. The LEO satellites operate at an altitude of 750 km. Under this system our options are limited due to the extremely tight defensive constellation this operates on, however, there are strategies to punch a hole and fly a counter defensive missile/s through with minimal detection.

Mission Setup

Single MRBM Option

To create an opening for a single medium range ballistic missile (MRBM), we have planned out 4 essential ASAT launches in order to provide necessary cover from launch to landing. To determine the necessary satellites for removal, we started with an analysis of what satellites would detect the MRBM along its flight path, launched from the South Western Coast of Madagascar .

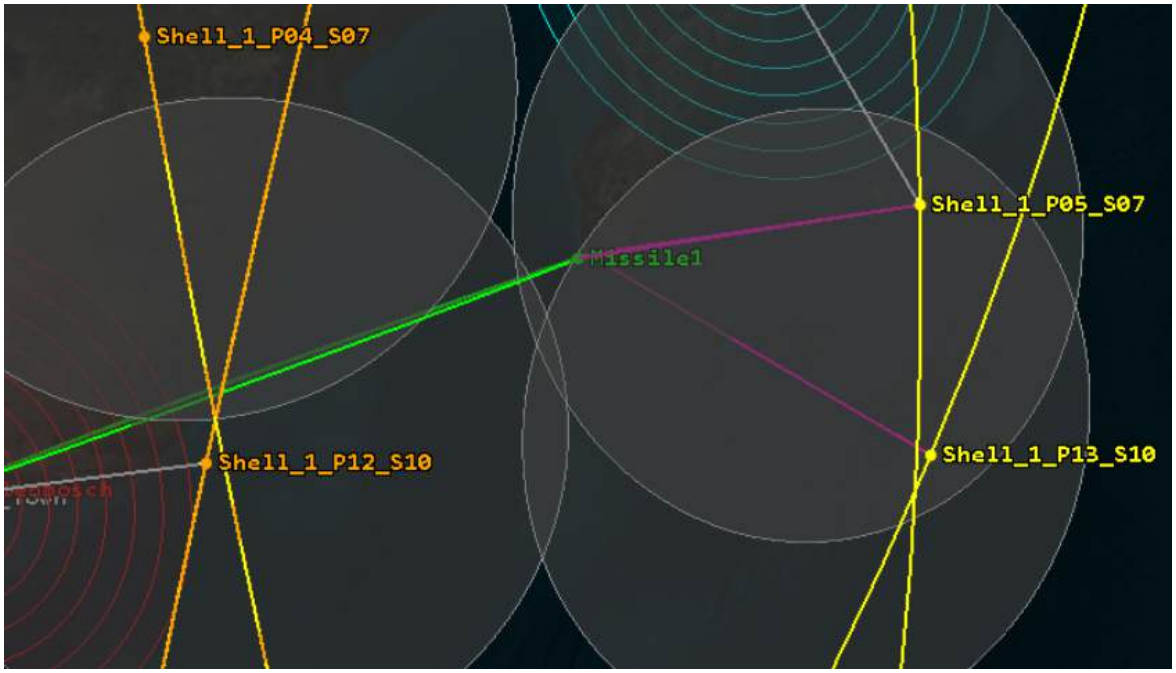
Proposed MRBM Launch specifications:
Launch Geodetic Longitude: 44.2728 deg
Launch Geodetic Latitude: -25.1125 deg
Launch Altitude: 0.12 km
Launch Time: 16 May 2025 18:35:45.000 UTCG
Launch Velocity: 4.70589 km/sec
Launch Elevation: 39.654 deg
Launch Azimuth: 243.933 deg
Max Altitude: 600 km
Desired Target: Air Force Base Ysterplaat
Target Geodetic Latitude: -33.9011 deg
Target Geodetic Longitude: 18.4833 deg
Impact Time: 16 May 2025 18:49:26.223

This target was chosen due to its relative prominence to other bases, its proximity to the large city of Stellenbosch as a show of capability, and the likelihood that this base holds the adversary's iron dome primary receivers.

Air Force Base Ysterplaat

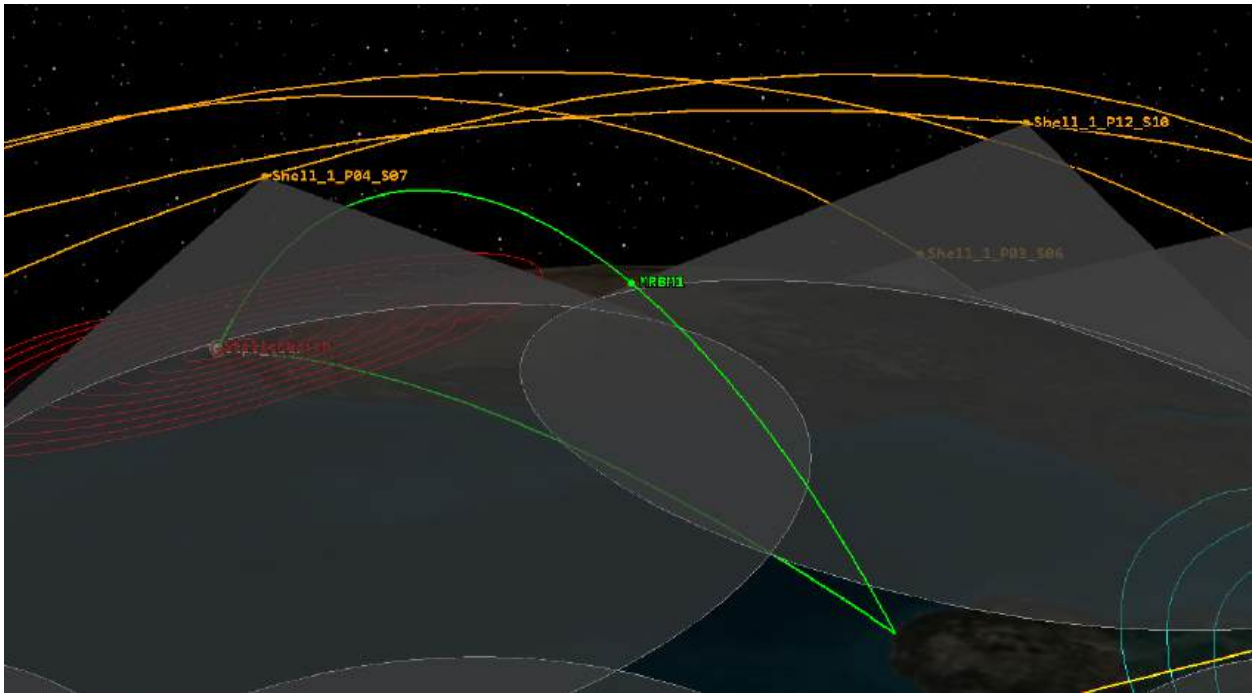
At Launch:

The MRBM would be detected by two LEO sensors: Shell_1_P05_S07 and Shell_1_P13_S10; and just narrowly missed by two others: Shell_1_P12_S10 and Shell_1_P04_S07.



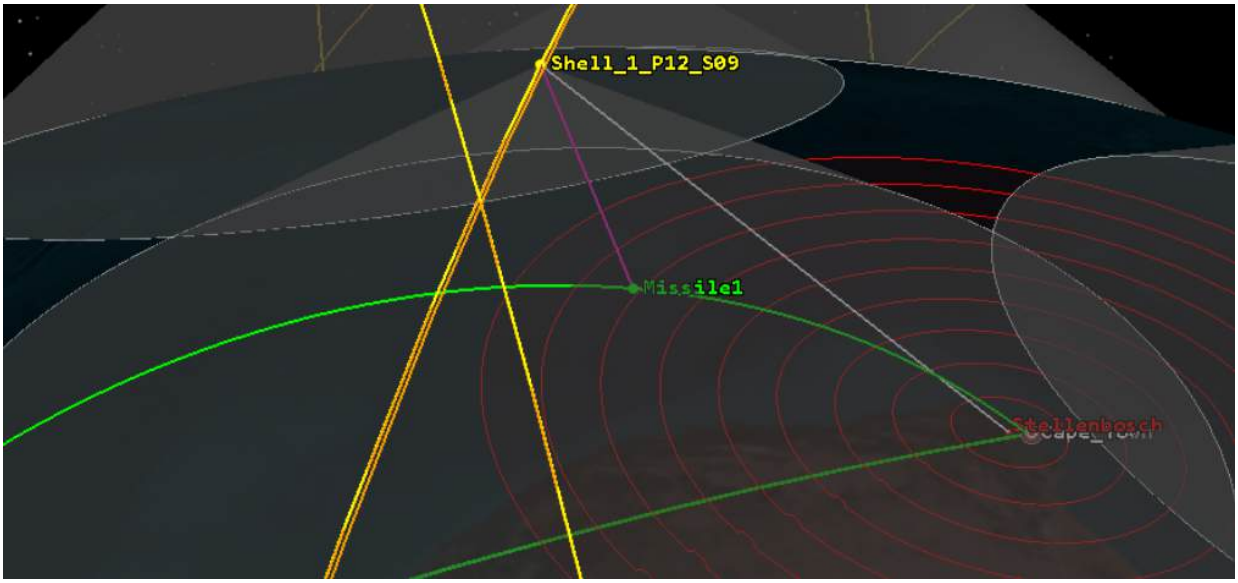
Crossing the Valley:

When transferring to the target, MRBM crosses the channel between the fields of regard for satellites Shell_1_P04_S07 and Shell_1_P12_S10 as they move apart.



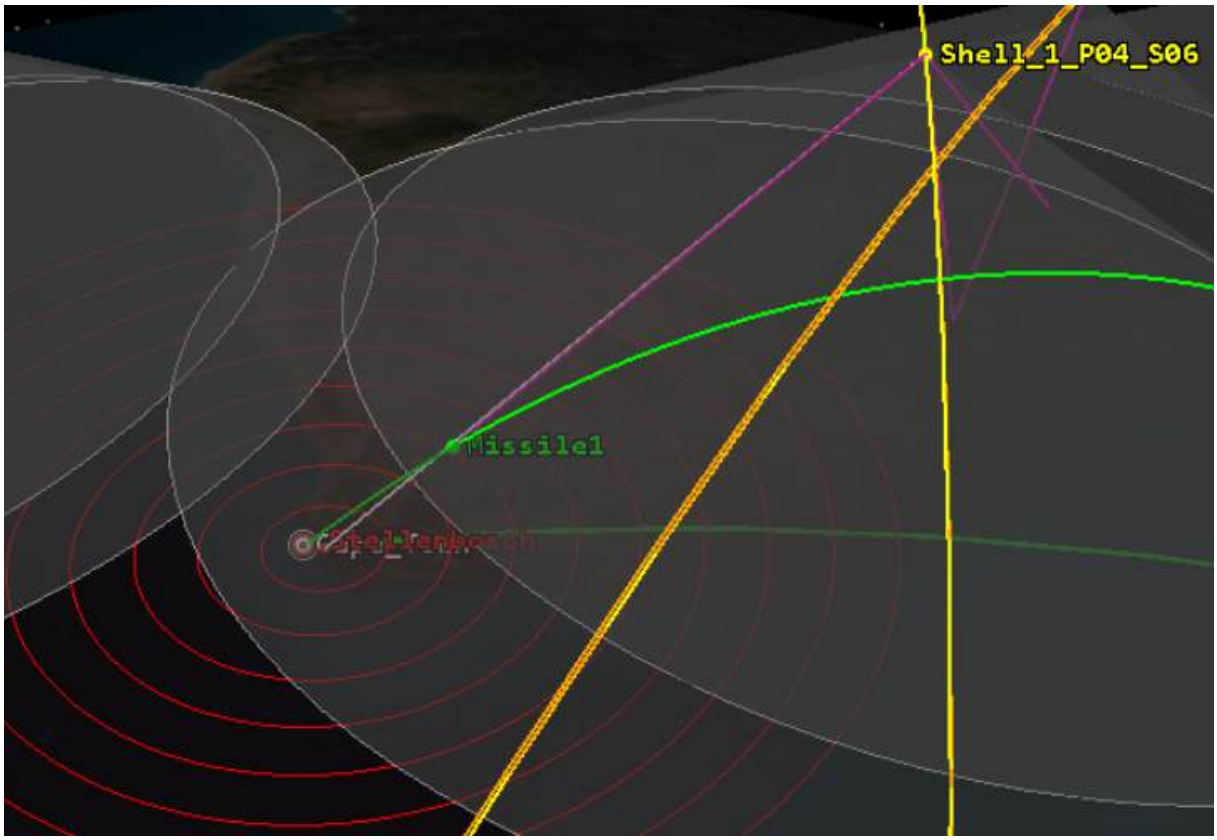
Mid Flight:

At approximately 18:45:27.000 on 16 May 2025, MRBM would be detected directly while passing under Shell_1_P12_S09.



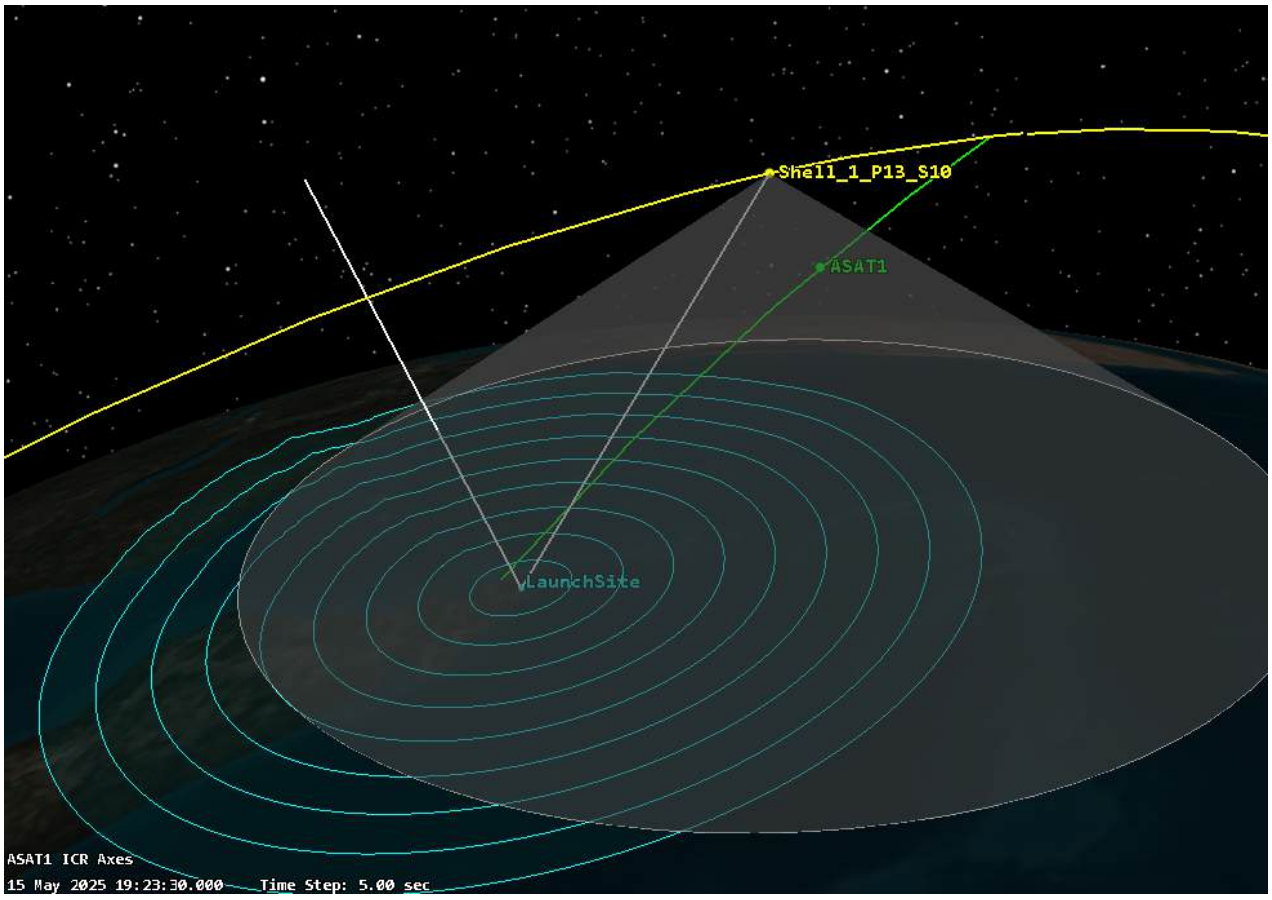
Landing:

MRBM would be accessed from 18:48:12 to landing at 18:49:26.223 by satellite: Shell_1_P04_S06.



To establish invisibility, ASATs will be deployed as defined below to eliminate the directly accessing tracking satellites:

ASAT #	**Launch Time**	**Flight Duration [sec]**	**Launch Azimuth** [deg]	**Launch Elevation** [deg]	**Launch Velocity** [m/s]	**Target**
ASAT 1	15 May 2025 19:21:00.000	240	-132.014	46.1197	7168.99	Shell_1_P13_S10
ASAT 2	16 May 2025 05:53:00.000	240	61.4197	14.0106	6536.19	Shell_1_P05_S07
ASAT 3	16 May 2025 16:52:00.000	240	177.517	49.0138	7355.18	Shell_1_P04_06
ASAT 4	16 May 2025 17:09:00.000	240	-136.901	17.2722	6020.43	Shell_1_P12_S09



ASAT1's Trajectory to Intercept Shell_1_P13_S10

While the satellites detailed above have confirmed access with the MRBM, we cannot be certain that the data we have on their field of regard data is accurate. This creates a potential need to disable additional satellites for the sake of guaranteeing minimal access data for the incoming MRBM as possible. For this, we selected 6 additional satellites that fall within a reasonable range to potentially achieve valuable positioning data. Any satellites outside of this group have been deemed to be an extremely unlikely threat due to their distance and angle from the MRBM for the duration of its flight. Detailed below are the 6 additional ASATs deemed reasonable to interfere with our mission if the adversaries FOR is larger than predicted by ~8 degrees.

Guarantee ASATs

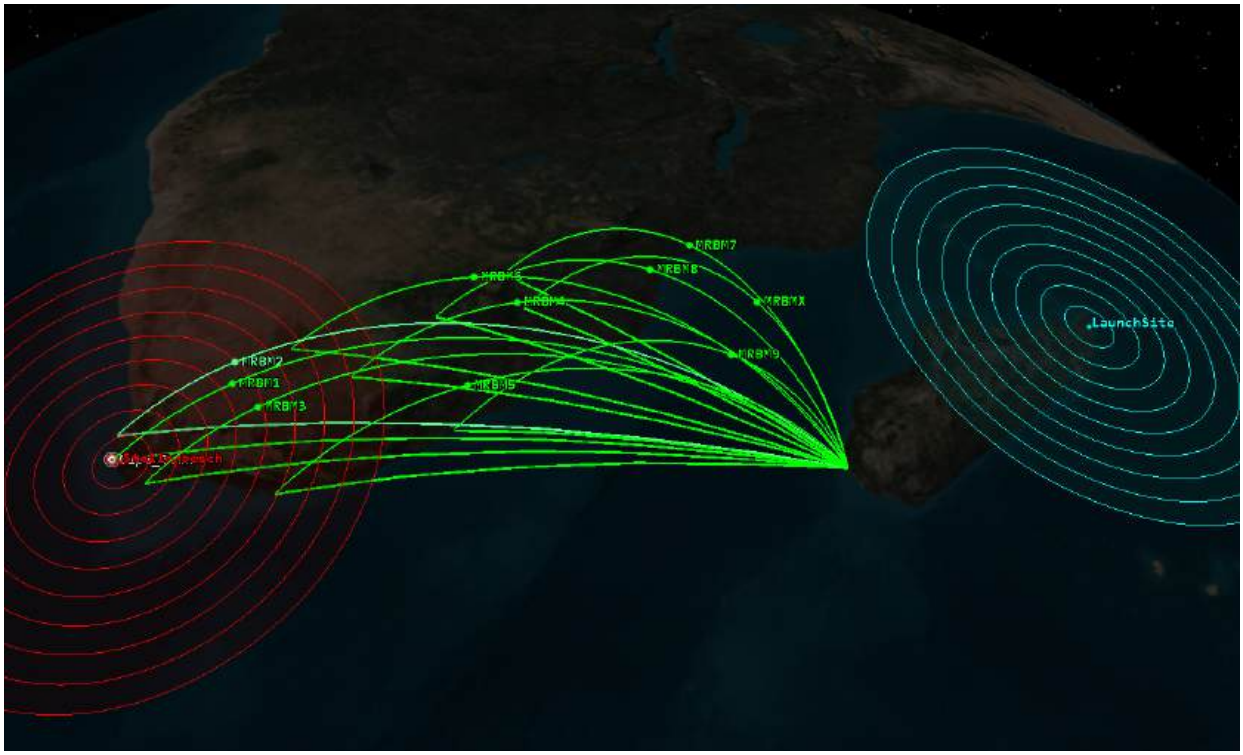
GASAT #	**Launch Time**	**Flight Duration [sec]**	**Launch Azimuth [deg]**	**Launch Elevation [deg]**	**Launch Velocity [m/s]**	**Target**
GASAT 1	16 May 2025 02:45:00.000	240	11.2447	7.12549	5961.01	Shell_1_P03_S06
GASAT 2	16 May 2025 04:15:00.000	240	39.3399	17.274	6985.37	Shell_1_P04_S07
GASAT 3	16 May 2025 04:44:00.000	240	-43.7387	22.6662	6211.98	Shell_1_P11_S09
GASAT 4	16 May 2025 06:33:30.000	240	-29.6498	18.2911	7195.9	Shell_1_P12_S08
GASAT 5	16 May 2025 06:17:00.000	240	-18.1967	27.1407	6360.24	Shell_1_P12_S10
GASAT 6	16 May 2025 17:07:30.000	240	167.064	36.9863	6131.54	Shell_1_P04_S05

This process would eliminate the “crossing of the valley” during the MRBM mid flight as well as clearing away nearby by sensors at landing, truly removing the fear of detection under larger FOR conditions.

10 MRBM Option

An expanded option is presented to target the 10 significant military bases in South Africa, including the target of the single MRBM option, being:

Location	Geodetic Latitude	Geodetic Longitude
South African Army Centre	-28.5000°	23.5000°
Air Force Base Makhado	-23.1600°	29.6967°
Air Force Base Overberg	-34.5547°	20.2506°
Tempe Military Base	-29.1000°	26.2167°
Air Force Base Ysterplaat	-33.9011°	18.4833°
Air Force Base Swartkop	-25.8069°	28.1644°
Air Force Base Hoedspruit	-24.3547°	31.0503°
Air Force Base Langebaanweg	-32.9689°	18.1653°
Air Force Station Port Elizabeth	-33.9900°	25.6103°
Air Force Base Durban	-29.9686°	30.9478°



Total Assault Pathing

For this goal, we plan to launch 10 total MRBM with the following launching conditions:

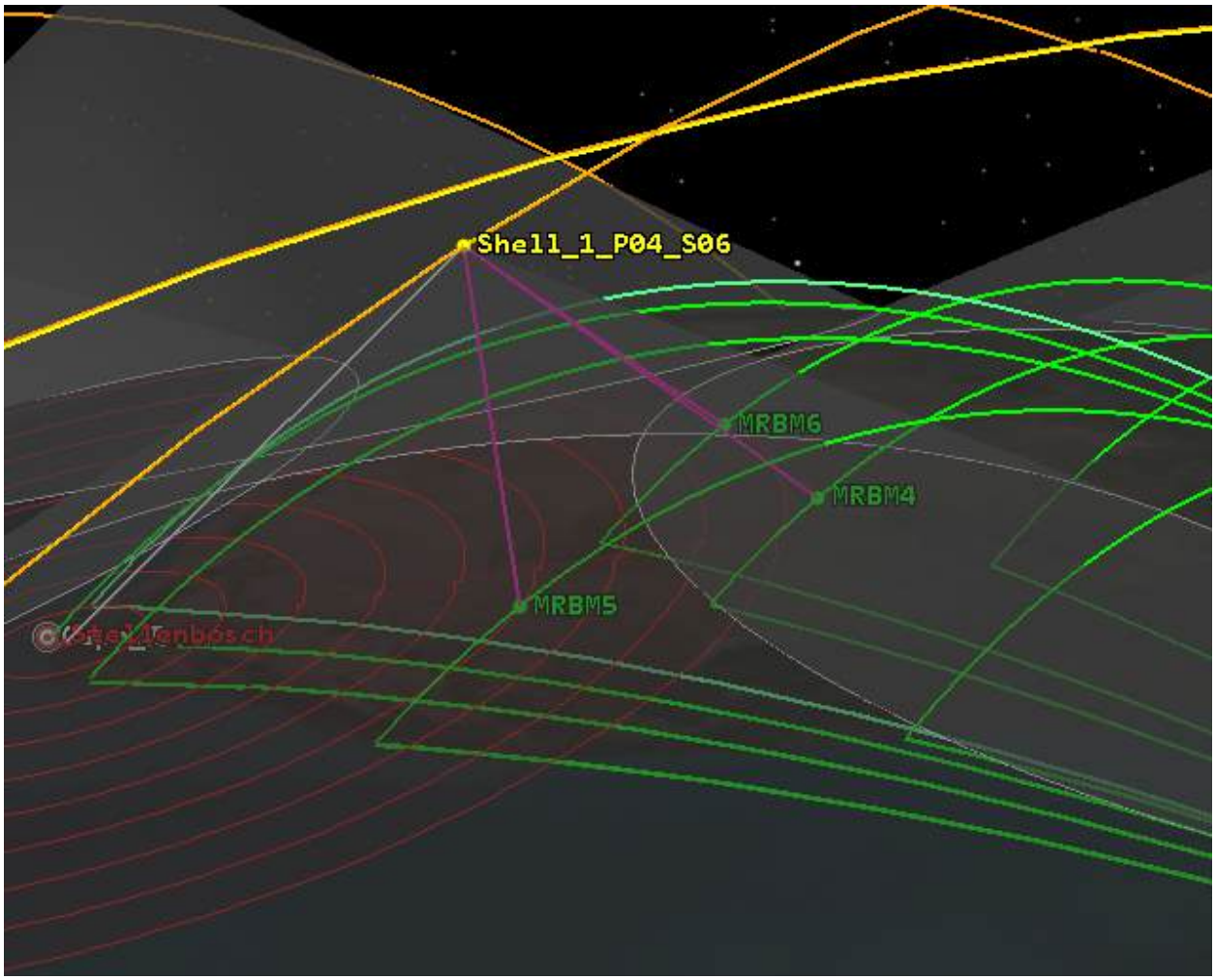
MRBM	**Launch Time**	**Impact Time**	**Launch Azimuth [deg]**	**Launch Elevation [deg]**	**Launch Velocity [km/s]**	**Target**
MRBM1	16 May 2025 18:35:45.000	16 May 2025 18:49:26.223	243.933	39.654	4.70589	*Air Force Base Ysterplaat*
MRBM2	16 May 2025 18:35:45.000	16 May 2025 18:49:26.127	246.319	39.608	4.71104	*Air Force Base Langebaanweg*
MRBM3	16 May 2025 18:35:45.000	16 May 2025 18:49:19.566	241.273	41.1497	4.60241	*Air Force Base Overberg*
MRBM4	16 May 2025 18:38:00.000	16 May 2025 18:51:02.517	253.278	50.6327	4.08381	*Tempe Military Base*
MRBM5	16 May 2025 18:38:00.000	16 May 2025 18:51:12.686	238.105	47.2903	4.23955	*Air Force Station Port Elizabeth*
MRBM6	16 May 2025 18:38:00.000	16 May 2025 18:51:12.489	256.381	46.759	4.27752	*South African Army Combat Training Centre*
MRBM7	16 May 2025 18:40:00.000	16 May 2025 18:52:51.236	276.858	56.3262	3.85113	*Air Force Base Makhado*
MRBM8	16 May 2025 18:40:00.000	16 May 2025 18:52:54.877	265.177	54.1409	3.93527	*Air Force Base Swartkop*
MRBM9	16 May 2025 18:42:00.000	16 May 2025 18:54:50.002	245.677	57.6839	3.79858	Air Force Base Durban
MRBM10	16 May 2025 18:42:00.000	16 May 2025 18:54:47.000	272.303	59.2663	3.74989	*Air Force Base Hoedspruit*

The total raid time on the launch end will last 6.25 minutes. The landing of the MRBM has been timed to create 4 “waves”, starting on the South Western side of the country and moving towards the North East.

To guarantee invisible transfer, we must once again analyze the flight paths to determine whether any additional satellites must be eliminated.

Wave 1: MRBM 1 - 3
These missiles follow a near identical flight path to the single MRBM option and require no additional satellite eliminations.

Wave 2: MRBM 4 - 6
These missiles would be accessed by the same satellites that were eliminated for Wave 1 and therefore require no additional satellite eliminations.



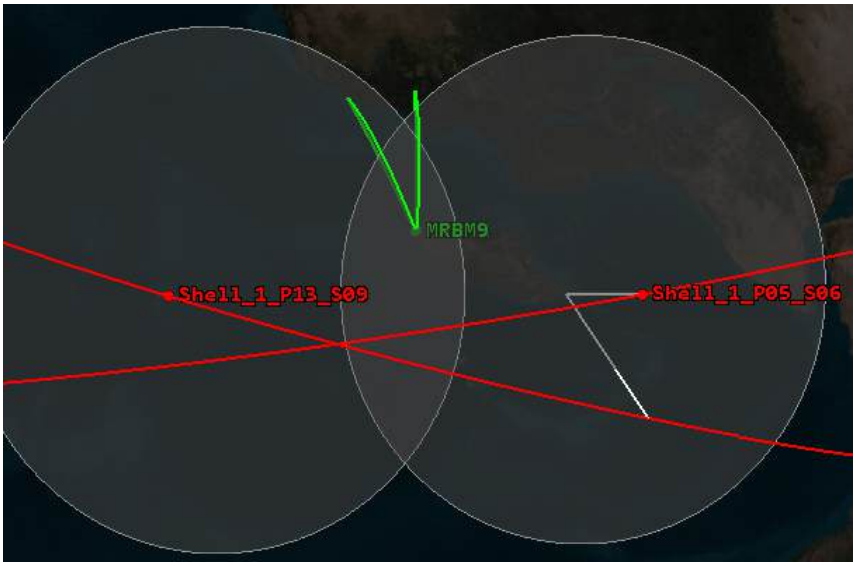
Wave 3: MRBM 7 & 8
These missiles go completely unaccessed for the duration of their flight.

Wave 4: MRBM 9 & 10
These missiles are not accessed by additional satellites until landing as seen in the picture below. MRBM 9 is accessed by Shell_1_P12_S08 directly. MRBM 10, on the other hand, does not appear to be accessed, however its position does overlap with the FOR of Shell_1_P04_S05.

Wave 4 Access At Landing

To address these accesses, GASATs 4 and 6 from the single MRBM option will be promoted from suggested to required. Additionally, 2 other satellites are suggested for uncertainty in the FOR, being:

GASAT2 #	**Launch Time**	**Flight Duration [sec]**	**Launch Azimuth [deg]**	**Launch Elevation [deg]**	**Launch Velocity [m/s]**	**Target**
GASAT2 1	16 May 2025 06:21:30.000	330	80.5127	24.3479	7567.82	Shell_1_P03_S09
GASAT2 2	16 May 2025 06:05:00.000	240	53.7282	30.7771	6731.22	Shell_1_P05_S06



Potential Access Region at Launch of Wave 4

Budget Analysis

Looking to previously established missions, we have developed preliminary budgets for each mission option. This mission budget assumes ASATs will be constructed from modified missiles, similar to the Indian Mission Shakti, and that Madagascar has all necessary infrastructure in place aside from the missiles themselves:

Single MRBM Option:

Essential ASATs: ~$20 million/satellite, $80 million total[1]
1 MRBM: ~$8 million[1]
Contingency: 30%, ~$27 million
Total: $115 Million

Including Suggested

Suggested ASATs: ~$120 million [1]
Contingency: 30%, ~$63 million
Total: $271 Million

10 MRBM Option:

Essential ASATs: ~$20 million/satellite, $120 million total[1]
10 MRBM: ~$8 million/missile, $80 million[1]
Contingency: 30%, 60
Total: $260 Million

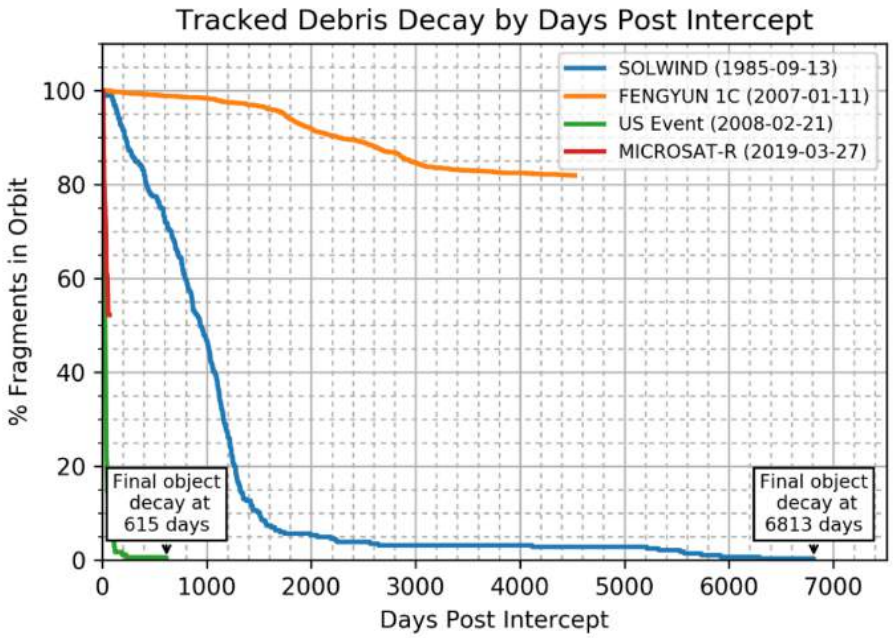
Including Suggested

Suggested ASATs: ~$120 million[1]
Contingency: 30%, 96
Total: $416 Million

Conclusion

With conflict tensions so high, decisions often must be made quickly, however, it is important to consider the long term effects of such actions. In the case of this mission, deciding to use KKV ASATs to punch a hole in South Africa's Iron Dome defense system can have significant and long lasting effects on the state of space usage, exploration, and science due to the extreme volume of debris this mission would create. Looking at the Chinese FY-1C ASAT test, a single KKV ASAT was able to create generational amounts of high energy debris which makes the area around Earth significantly more difficult to traverse and utilize, as detailed in the graph below[2]. Considering this, we suggest, if time allows, research and preparation into non-KKV options like co-orbital satellite disabling or data manipulation. One major feature of the Iron Dome is its use of GEO guiding satellites which tell the high resolution LEO satellites where to point. This feature can likely be taken advantage of through data spoofing to force the LEO observers to “look away” from incoming MRBM.

The solutions offered in the proposal are quick and reliable in comparison to other alternatives and stand as a strong last resort procedure in the event of sudden conflict with South Africa, that being said, we fully support the consideration of other options if the situation allows for it as the conflict unfolds.



Figures Comparing Various KKV Mission Debris:
FENGYUN 1C is the ASAT of Relevance[2]

Works Cited:

[1] Kumar, A. (n.d.). *India's Agni missiles*. Focus Global Reporter. https://focusglobalreporter.org/indias-agni-missiles/

[2] Abraham, A. J. (2019). *Evaluation of the 27 March 2019 Indian ASAT demonstration* (AAS 19-942). The Aerospace Corporation. https://aerospace.org/sites/default/files/2019-09/Abraham_Evaluation27March2019_092419.pdf