核ミサイルの脅威を無にする宇宙システムの一案

－世界から核ミサイルの脅威を無くすために－

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あらまし

2016年に国連決議された核兵器禁止条約は所謂核保有国からは無視されている。また唯一の核被爆国である日本国政府も非現実的であるとして反対している。人類が核兵器の脅威の下にある事は冷厳な現実であるが核兵器の脅威を無くするにはどうすれば良いであろうか。核兵器はその運搬手段が無力化されれば兵器としての意味を失う。そこで何時でも何処でも発射されたミサイルを検知、追尾、捕獲、発射元に返す方法を提案する。先ず二個以上の衛星で地上を常時観測しミサイルの発射を即時検知する。ミサイルの高度が上がると遠方から遠距離レーダで補足、追尾する。数千kmの彼方から大きさ数メートルの飛翔体を検知、追尾するには送信電力と共に受信装置の利得を十分上げなくてはならないが、単にアンテナ利得を上げると指向性が鋭くなって観測できる地理的範囲が狭くなる。ここではこの二律背反問題を複数の受信装置の出力信号を監視方向に対応した複素係数を掛けて同相合成する方法で解決する。観測されたミサイルの高度、位置、速度から軌道を計算し、自国に対する攻撃である事を確認したら防衛ミサイルを発射する。ここでは一般の迎撃ミサイルのように目標ミサイルを打ち落とすのではなく目標ミサイルと併走して捕獲する方法を提案する。捕獲法は迎撃法より命中精度が上げられるばかりでなく当ミサイルを発射元に返す事も可能である。もしそれが実現すれば核兵器は軍事的には無意味になり人類は核兵器の脅威から解放されるであろう。

キーワード

核爆弾，大陸間弾道弾、ミサイル防衛、ミサイル迎撃、監視衛星、遠距離レーダー、ロケット、方向転換

A Space System to Nullify Threats of Nuclear Missiles

－For elimination of the threat of nuclear war－

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Abstract

The nuclear weapons ban treaty agreed in **UN** in 2016 is neglected by so-called nuclear powers countries. Even Japan, the only victim of atomic bombs explosion in WW2, her current government opposes it as unrealistic. It is a hard fact that the world is under the threats of the terrible nuclear weapons. How can we eliminate the threats?　Nuclear weapons become useless if their transportation means are nullified. Here is proposed a system that can immediately detect, track, capture and return the missiles to their launchers. The launch of a missile is immediately discovered by at most two reconnaissance satellites.　As the missile gets sufficiently high, it can be monitored from afar by long distance RADAR systems. Once the offence missile is recognized, the missile defense system will launch a defense missile. Unlike the existing systems, the defense missile does not hit but capture the offense missile to destroy it in space or send it back to the launcher.

Keywords Nuclear weapons, ICBM, Reconnaissance satellites, Long distance RADAR, Hitting, Docking, Return

1. Immediate detection of missile launch

Two pictures taken by two separate satellites are compared to detect the launch and position of the nuclear missile by the following methods. The vectors are defined by the coordinates with the origin at any fixed point.

Let the following parameters be;

Coordinates of the missile; $r = (x, y, z)$

Coordinate of Satellite A ; $ra = (xa, ya, za)$,

Position A' of the missile on the picture taken by satellite A; $Ra = (Xa, Ya, Za)$,

Straight line vector connecting A' and A; $a = ra - Ra$

Similar vectors are defined for satellite B as rb, Rb and b.

Then the position of the missile can be detected as the intersection of the following two vectors.

Straight line AA' ; $ra + t \cdot a \quad (0 < t < 1)$

Straight line BB' ; $rb + u \cdot b \quad (0 < u < 1)$

By setting

$$ra + t \cdot a = rb + u \cdot b$$

The solution is;

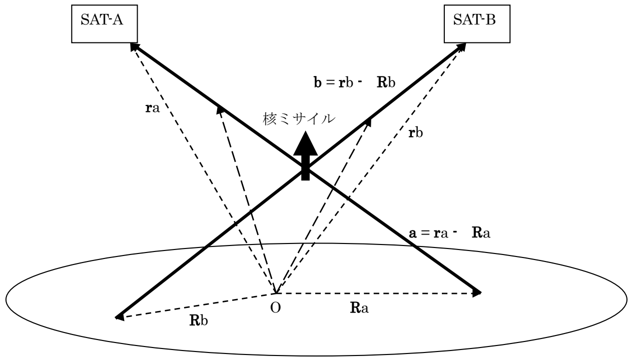
$$ta = (rb - ra) \cdot \{ (a \times b) \times b \} / \{ (a \cdot b) \cdot (a \cdot b) - (a \cdot a) \cdot (b \cdot b) \}$$

$$ub = (ra - rb) \cdot \{ (b \times a) \times a \} / \{ (a \cdot b) \cdot (a \cdot b) - (a \cdot a) \cdot (b \cdot b) \}$$

where $a \cdot b$, $b \times a$ are scalar and vector products of vectors a, b.

The position of the missile is then given by

$$r = ra + ta \cdot a = rb + ub \cdot b$$



2. Long Range RADAR

As the altitude of the offense missile gets sufficiently high, it becomes possible to be monitored by the long range RADAR system.

[1] Target capability

— Velocity in view of the missile ; up to 6,000 (m/s)

— Range of measurement ; Up to 3,000km

[2] System description

PN code modulated signal is transmitted for 10ms and the reflected waves from any objects received and monitored for 20ms. With different PN codes it is possible for multiple RADAR stations to share the same frequency. Three separate RADAR stations are needed to determine the position of the target missile.

For exact integration of the receive PN coded signal, the phase of the signal needs to remain constant during the integration. Therefore the frequency errors should be sufficiently smaller than the inverse of the signal duration (10ms), or 100Hz. The Doppler frequency shifts can be much greater than 100(Hz), hence the correlation integration of the PN code shall be made for signals frequency converted to baseband in 10Hz steps.

Comparing the PN correlation detected signals with the transmit signal, the time delays and frequency differences can tell the distance and speed in view of the target missile.

[3] Radio Frequency

The RADAR must have very small rain attenuation for its long ranges of observation. The size of the target nuclear head will be in a few meters. For those reasons a radio wave with 1 meter wave length is assumed in the design.

[4] Link Power Budget

Let transmit(TX) power be Pt, TX antenna gain; Gt, distance to the target; d, radar aperture of the target; σ、 aperture of the receive(RX) antenna; Ar.

Then the signal power obtained at the output of the receive antenna is given by the equation;

$$Pr = Pt \cdot Gt / (4\pi \cdot d^2) \cdot \sigma / (4\pi \cdot d^2) \cdot Ar$$

The design figures are given in the following table.

Table 1 RADAR system parameters

Target	Distance d (km)	1500
	Maximum Speed (m/s)	6000
Transmitter	TX Power Pt (dBW)	40
	TX antenna gain Gt (dBi)	20
Forward path loss	Distance d (km)	1500
	$1/(4\pi . d^2)$ (dB/m^2)	-134.5
Target radar aperture	σ (m^2)	10
Return path loss	Distance d (km)	1500
	$1/(4\pi . d^2)$ (dB/m^2)	-134.5
RX antenna	Effective antenna aperture Ar (dBm^2)	20
	RX power at antenna output Pr (dBW)	-179
Thermal noise	Rx system temperature (dBK)	20
	Boltzman constant ($k=1.33x10^{-23}$) (dB)	-228.6
	Noise power spectrum density No (dBW/Hz)	-208.6
Communication capacity	C/No (dB/Hz)	29.6

[5] TX antenna

The effective aperture Ae of the antenna with antenna gain 20 dBi is;

$$Ae = (\lambda^2 / 4\pi) \cdot G = 7.96 \ (m^2)$$

Parabolic antenna with diameter 3.2(m)

[6] RX antenna

The antenna with effective aperture of 100m^2 (20dBm^2) is physically difficult to realize in one antenna. Even if possible it raises another problem of a very narrow coverage.

The antenna gain with the specified effective antenna aperture is;

$$G = (4\pi / \lambda^2) \cdot Ar = 400\pi = 31.0 (dBi)$$

The directivity, or solid angle,

$$\Omega = 4\pi / G = 0.01 \ (grad)$$

which gives the view angle

$$\theta = 2\sqrt{(\Omega / \pi)} = 0.113 \ (rad) = 6.4 (deg)$$

That covers about 170km with distance 1500km. The coverage is too narrow and requires multiple antennae of the type to cover the target areas.

[7] Receiver

The receive antenna poses the following problem.

Problem; How can one realize a receiver with high gain and wide area coverage?

Solution; Use multiple receivers with lower gain antennae and combine the outputs.

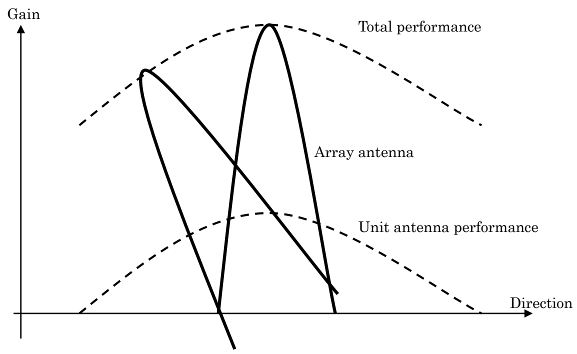
We will use the antennae with the same parameters as the TX antenna. Let the effective antennae apertures of the TX, and RX antennae by Ae and Ar, then the required number of the receivers is

$$Ar / Ae = 100 / 7.96 = 12.6$$

Namely 13 receivers are required to meet the specification.

The outputs of the receiver antennae are respectively demodulated, sampled by system clocks and A/D converted. The A/D converted samples are combined with proper coefficients for different directions.

This technology is called synthetic aperture antenna (SAA) widely used in long ranges radar systems. The performance of SAA is depicted in the following figure.



[8] Pulse compression system

<> Pulse width $\Delta t = 1.2\mu s$

<> Spectrum spreading code PN code

<> PN code

- Code length 2^13
- time period 10ms
- Chip rate 819.2kc/s
- Modulation Direct spreading (BPSK)

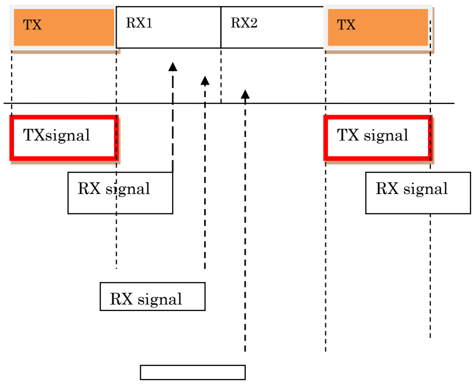
<> PN code correlation detector

-Impulse recovery by PN correlation detection

-Frequency spectrum analysis in 10Hz steps

[9] RADAR system time frame

The RADAR time frame consists of 10ms TX, 10ms RX1 and 10ms RX2. RX1, 2 receive the radio waves reflected from the targets up to 1500 and 3000km away.



[10] Pulse processing

◇ TX PN signal

The PN signal triggered at time t= 0 is;

$$P(t)= [m=0,M-1]\,\Sigma\, P(m)\cdot g(t - m\cdot T)$$

Where {P(m)=1, or -1 ; m= 0,1,2,,,,M-1} are PN codes and the pulse shape g(t) is,

$$g(t) = 1 \quad (-T/2 < t < T/2) \qquad (T;\ \text{pulse duration})$$
$$= 0 \quad (\text{otherwise})$$

◇ RX PN signal

The receive signal reflected from an object at a distance d is given by,

$$Q(t) = e\hat{}(j\,\omega d.t).P(t - 2d/c)$$

where ωd is the Doppler shifted angular frequency.

◇ PN correlation detection of receive signal

The receive signal Q(t) is PN correlation integrated to give the pulse compressed output Q'(t);

$$Q'(t) =[m, m' = 0,M-1]\,\Sigma\, P(m')\cdot Q(t + m'\cdot T)$$
$$= [m,m' =0,M-1]\,\Sigma\,\Sigma\, P(m)\cdot P(m')\cdot e\hat{}(j\,\omega d.(t+ m'\cdot T))$$
$$\cdot\, g(t- (m-m')\cdot T - 2d/c)$$
$$= e\hat{}(j\,\omega d.t)[m,m' =0,M-1]\ \Sigma\,\Sigma\, P(m)\cdot P(m')$$
$$\cdot\, e\hat{}(j\,\omega d.\ m'\cdot T))\ g(t - (m-m')\cdot T- 2d/c)$$

The maximum correlation is achieved for m= m' ;

$$Q'(t) = e\hat{}(j\,\omega d.t).\ g(t - 2d/c)$$
$$\cdot\, [m=0,M-1]\,\Sigma\, e\hat{}(-j\,\omega d.\ m\cdot T)$$
$$= e\hat{}(j\,\omega d.(t-(M-1)T/2)).$$
$$\cdot\, \sin(\omega d.T.M /2) / \sin(\omega d.T /2)\cdot g(t - 2d/c)$$

By comparison with the transmit timing, the waveform g(t - 2d/c) gives the distance d to the object.

◇ Doppler frequency shifts

For RF frequency fr = 300MHz, the speed in view of the objects 6000m/s, the Doppler frequency caused is 6,000Hz. On the other hand the PN detection function is in the following form;

$$\sin(\omega d.T.M / 2) / \sin(\omega d.T / 2) = \sin(\pi\, fd.T.M) / \sin(\pi\, fd.T)$$

It tells that it must meet $\lvert \pi\, fd.T.M \rvert << 1$ to give good response.

With T.M =10(ms), it must meet $\lvert fd \rvert << 100/\pi$ (=) 30(Hz)

◇ Frequency analyzer type PN detector

In order to meet the above conditions, we conduct frequency analyzing and PN correlation detection for frequency steps Δf = 10Hz.

The receive signal is frequency shifted k.Δf to 0(Hz) for k=0,1,-1,2,-2,,,.to get the output R[k](t);

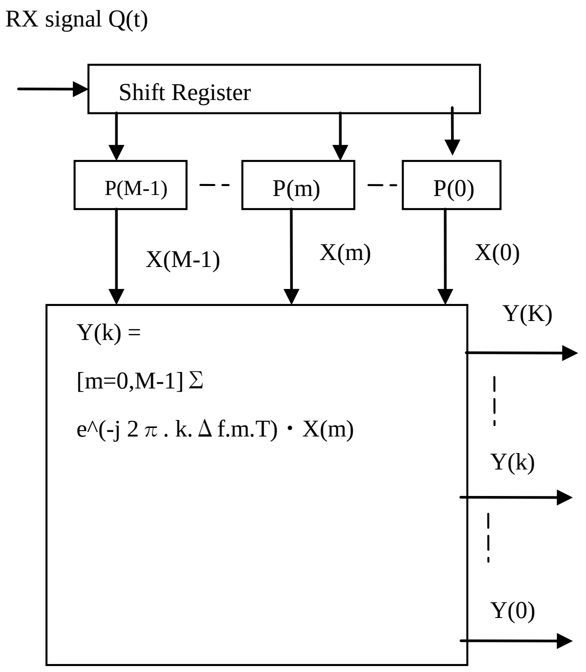
$R[k](t) = [m'=0,M-1]\, \Sigma\, P(m')$

$\cdot\, e^{\wedge}(-j2\pi .k.\Delta f.\, m'.T) \cdot Q(t+m' \cdot T)$ (k= +,-1,2,3,,,)

With the 10(Hz) step the speed of the object is measured with the precision;

$V = c \cdot fd / fr = 3x1o^{\wedge}8 \text{ x } 10 / 300(MHz) = 10 \text{ (m/s)}$

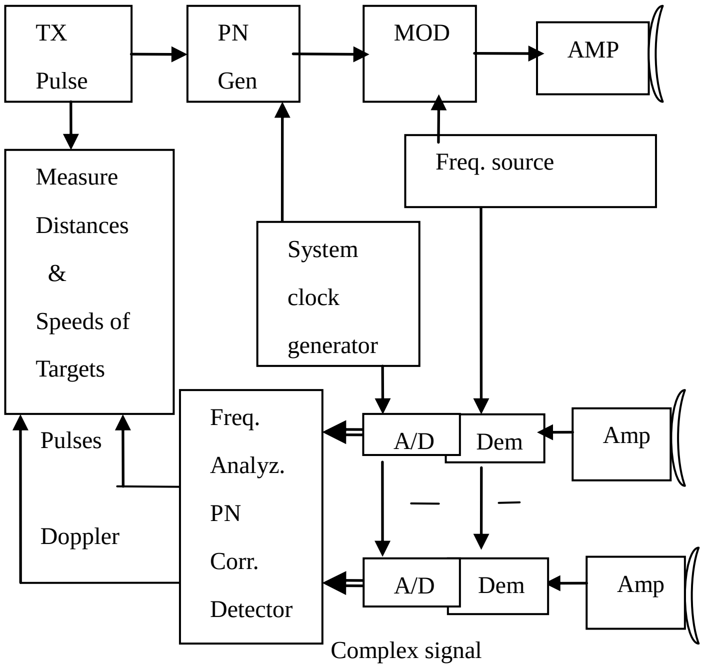
A block diagram of the frequency analyzer-PN detector is given in the following figure.



Frequency Analyzing PN Detector

[11] Configuration of Radar Station

The structure of the distance radar station is depicted in the following figure. Data from three radar stations are collected at the center to calculate the position of the flying objects.



Configuration of RADAR station

3. Missiles Capturing System

[1] Conventional missiles defenses methods

The conventional defense missiles hit the offense missiles on orbits to destroy them. Considering their immense speeds, it seems technically difficult to hit the targets with a perfect certainty.

[2] Missiles capturing methods

It is proposed herein not to hit but to run side by side, close in and capture the targets nuclear war heads in the space. This is technically established and daily used in space systems today as docking of space rockets.

[3] Changing directions of objects in space

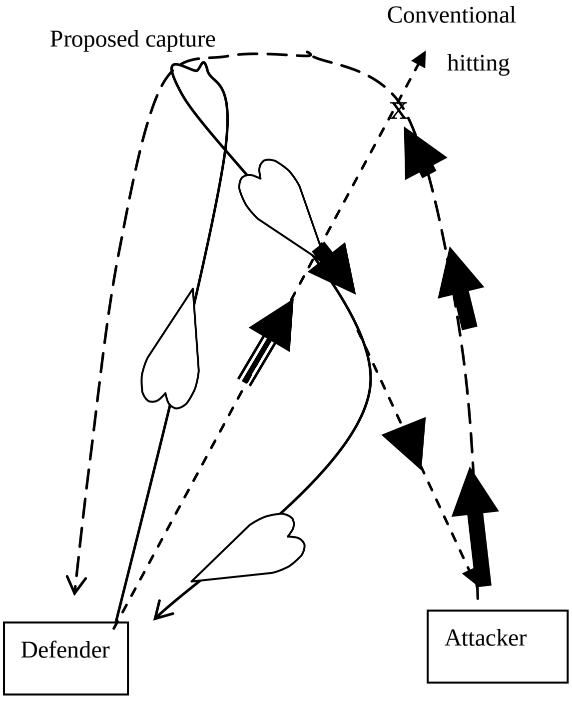
We can reverse the direction of the flying object with mass m and velocity v by applying the momentum -2mv.

Suppose we apply a constant force f to the object which causes acceleration a = f/m, which then generates a velocity u = a.t = f/m.t. The direction of the object is reversed at time t = T when u = f/m.T = -2v or f.T = -2m.v.

Suppose we try to change the direction of an object with mass m= 10(ton) and speed v = 2,000 (m/s) in 100 seconds, then we need to apply the force f to the object;

$$f = 2m.v / T = 200 \text{ (tonf)}$$

The function of the proposed system is depicted in thefollowing figure.



Nuclear missile defenses systems

[4] Requirements for the defense missiles

(1) Solid and liquid fuel engines of the rocket

The defense missile must be ready to be launched at any time. The booster stage can be of a solid fuel engine but the space rocket part needs to be of liquid fuel type as it must change its direction and speed freely in space. Thus a development task is for a liquid fuel engine which is ready to operate at any time and safe for practical operations.

Other development tasks include automatic attitude, adaptive engine output and navigation controls. Another item is the capability of communication, commands and responses between the defense missiles and the terrestrial command stations.

Still another development item is naturally the mechanism for capturing, transporting the warheads back to the launchers or destroying them in space.

In the following analysis we assume a defense missile with a booster rocket of solid fuel to lift the defense missile quickly to the required altitude. After separation of the booster engine the higher stages engines are fully controllable of the thruster power.

4. Operational Steps of the proposed missile defenses

[1] Determination of orbits of the attacking missiles

The satellites and long range RADAR systems described in the previous chapters establish the orbits of the attacking missiles or warheads based on the observations.

On detection of being attacked, the control station commands the defense system to initiate the missile defense operations.

In the following operations the spherical coordinate system is adopted with the origin at the center and matches the latitudes and longitudes on the surface of the earth.

[2] Decision of the times and states in the steps of defense

The control station commands the missile defense system to initiate the defenses operations in the following steps and parameters.

Step 1 Launch of defense missile

to ;　Time of the launch

rm(to) ; Location vector of the missile base

am; acceleration vector of the defense missile

Step 2 Capture the target

t1 ; Time of separation of the booster rocket

rm(t1) ; position of the missile at t1

vm(t1) ; Velocity vector of the missile at t1

tf ; time to capture the target at;

Ra ; position of the missile at tf

Va ; velocity of the missile at tf

Step 3 Reverse the velocity to zero

tb ; time to bring the velocity to zero

rj(tb) ; position of the joint target and the missile

Step 4 Return the warhead to the sender

tr ; time to return the warhead to the sender

Rs ; positional vector of the sender’s location

5. Functions in the defenses steps

Step 1 Launch of the defense missile

The defense missile is launched at to and the booster stage is separated at t1. Let Ti be the duration of the burn of the booster stage, then

$$t1 = to + Ti$$

Let f and M be the thrusting force and mass of the defense missile, then the acceleration vector am is given;

$$am = f / M - g$$

where g is the acceleration vector of the gravity toward the center of the earth.

The velocity and positional vectors of the missile at t1 are;

$$vm(t1) = am.(ti-to) = am.Ti$$

$$rm(t1) = rm(to) + am.Ti^2 / 2$$

The energy consumed in this step is

$$E1 = [to, t1] \int f.v(t)dt$$

$$= M.(am +g).am.Ti^2 / 2$$

Step2 Capture the target

Let am’ be the acceleration during this stage, then

The velocity at tf must be

$$vm(tf) = vm(t1) + am'.(tf - t1) = Va$$

The positional vector at tf must be ;

$$rm(tf) = rm(t1) + am'.(tr - t1)^2/2 = Ra$$

The above relations determine the required acceleration vectors am and am’ as follows;

$$am' = \{ 2(Ra - rm(to)) - Va.Ti \} / \{ (tf - to - Ti).(tf - to - 2Ti) \}$$

$$am = \{ Va.(tf - to - Ti) - 2(Ra - rm(to)) \} / \{ Ti.(tf - to - 2Ti) \}$$

Let the thrusting force and mass of the missile in step 2 be f’, M’, then the acceleration am’ is given;

$$f' / M' - g = am'$$

The energy consumed in step 2 is;

$$E2 = [t1, tf] \int M' (am' + g). (v(t1) + am' (t - t1))dt$$

$$= M'. (am' + g). (tf - to- Ti).\{ am.Ti + am'(tf - to - Ti) / 2 \}$$

Step 3 Reverse the velocity to zero

The defense missile captures the target warhead, reveres the momentum till the velocity reaches zero.

The velocity condition is;

$$Va + b.(tb - tf) = 0$$

where b is the acceleration vector during this step.

The position at tb is

$$rj(tb) = Ra + Va(tb- tf) + b.(tb - tf)^2 /2$$

Let the thrusting force and joint mass of the target warhead ad the defense missile in this step be f” and M”, then

$$f'' / M'' - g = b$$

The energy consumed in this step is

$$E3 = [tf, tb] \int f''. v(t)dt$$

$$= M'' Va . (g.(tb- tf) - Va)$$

Step 4. Return the warhead to the sender (owner)

Let Rs be the positional vector of the sender.

Let the thruster force and joint mass of the target warhead and the defense missile and the acceleration vector of the joint mass be f''' and M''' and b', then

$$Rs = rj(tb) + b'.(tr - tb)^2 /2$$

$$f'''/ M''' - g = b'$$

The path from $rj(tb)$ to Rs is expressed as;

$$Rs - rj(tb) = f'''/M''' (tr - tb)^2 /2 - g.(tr - tb)^2/ 2$$

The above second term is the free fall due to the gravity. Thus the rocket needs to thrust only in horizontal direction.

The energy consumed in step 4 is

$$E4 = [tb, tr] \int f'''.b'.t.dt$$

$$= M'''(Rs - rj(tb)).(g + 2(Rs - tj(tb)) / (tr - tb)^2)$$

6. Conclusion

The proposed system can capture the nuclear warheads with a certainty by applying the docking technology of the space rockets. The immediate detection of the attacking missiles launches by the satellites and the continuous tracking of their flights by long ranges radar systems enable early determination of their orbits and aims and initiation of the missile defense system with sufficient time margin.

The application of the docking technology of space rockets ensures capture of the horrible warheads with quite a certainty. The certain capability of returning the warheads to the senders will nullify threats of the nuclear weapons systems.

Benefits of the proposed system are not limited to military but wide range of civil applications. The satellites system is useful for continuous monitoring of the globe. Bush fires can be detected at the earliest stage to prevent spreading of damages. The long range radar system can be used for air traffic control over wide areas. Because of their global scale coverage an international cooperation in civil applications will be beneficial as well as the nuclear missiles nullification.

The author sincerely wishes that the proposed system will be developed and deployed widely to nullify the nuclear missile systems to certify the peace of the world.

References

[1] Osamu Ichiyoshi “ A Space System to Nullify the Threats of Nuclear Weapons “ (in Japanese)
IEICE technical report , SANE2017-105 (2018-01)

[2] Y.Mushiake,
Antenna and Radio Wave Propagation ,
1960, Corona Pub.(in Japanese)

[3] M. Miyazawa
Introduction to Space Rockets Technology
2016, Asakura Shoten Co.Ltd(in Japanese)

[4] Journal of defense technology
Essence of missile technology
2006 (in Japanese)