平和と安全のための宇宙システム
－人為及び自然災害の防止の為に－

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あらまし
現在宇宙の軍事利用の危険が増している。核弾頭を運搬する大陸間弾道ミサイルや Radar による検知を免れるための cruise ミサイルの開発も憂慮すべき状況にある。人類の共有財産たる宇宙は平和と安全のためにこそ用いられるべきであろう。筆者は先に何時でも何処でも発射された核ミサイルを即時検知、追尾、捕獲、発射元に返す方法を提案した[1]。その方法はミサイル発射を即時検出する衛星システム、高空を飛翔する核ミサイルを遠方から監視、追尾する遠距離 RADAR システム及び核ミサイルを捕獲して発射元に返送する捕獲ロケットシステムの三者なるミサイル防衛システムである[2]。核弾頭に真っ向から衝突して破壊する方法もある。Cruise ミサイルは低空で飛行し遠隔 RADAR による追跡が困難であるため、特に衛星による監視が重要である。本稿においては提案システムの概要と特に衛星システムの課題について検討した結果を報告する。本提案のシステムは宇宙からの地球観測システムであり軍事的脅威に限らず自然災害の監視や防止にも有効な平和と安全のためのシステムである。本提案のシステムが早期に実現され人為的及び自然的災害が防止される事を筆者は切に願っている。

キーワード
核爆弾，大陸間弾道弾、ミサイル防衛、クルーズミサイル、監視衛星、遠距離レーダー、ロケット、方向転換

A Space System for Peace and Security
－　For elimination of man-made and natural disasters　－

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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. The cruise missiles hard to be detected by RADAR on the ground can be well monitored by satellites. Once the offence missile is recognized, the missile defense system will launch a defense rocket.　Unlike existing systems, the defense rockets 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
Cruise missiles, all time monitoring, infrared cameras, GEO,

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 the earth center.

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;

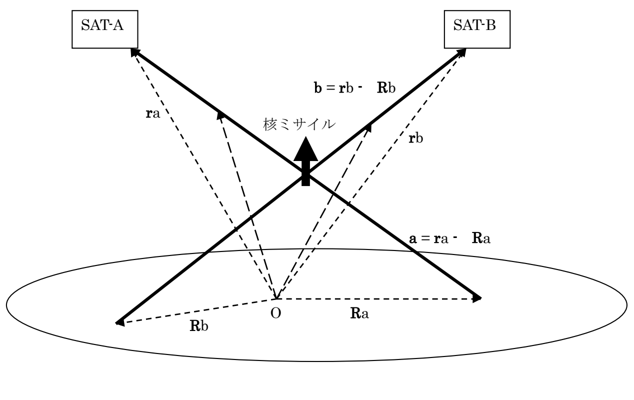
$$ta = (rb - ra) \cdot \{ (a \times b) \times b \} / \{ (a \cdot b) \cdot (a \cdot b) - (a \cdot a) \cdot (b \cdot b) \}$$

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

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 of the targets.

[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
	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
C/N in Pulse Detection	dB	9.6

[5] TX antenna

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

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

Parabolic antenna with diameter 3.2(m)

[6] RX antenna and Receiver

The antenna with effective aperture of 100m^2 (20dBm^2) is physically difficult to realize in one antenna. We need an antenna with contradictory features of a high gain and broad coverage. The problem is solved by antenna arrays technology. We will use the elements 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 antennae and receivers is

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

Namely 13 receivers are required.

[7] Pulse processing system

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

<> Spectrum spreading code PN code

<> PN code

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

◇ 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 of a rectangular,

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

◇ RX PN signal

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

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

where ωd is the Doppler shifted angular frequency.

◇ PN correlation detection of receive signal

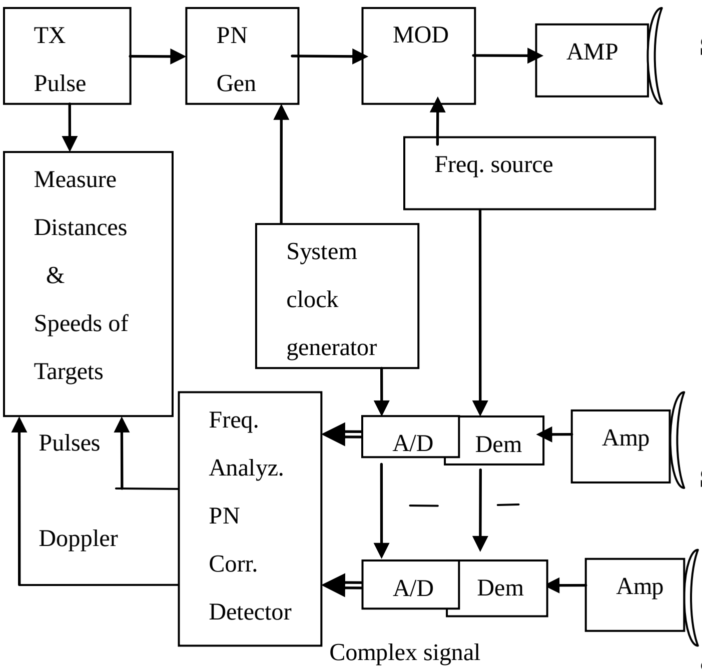
The receive signal Q(t) is PN correlation integrated to give the pulse compressed output Q'(t);

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

Note the auto-correlation property of PN sequence is used so only the terms m=m' above contribute to the detection of the receive signal thus achieving the pulse compression. The PN detection function above tells it should be $|\ \pi\, fd.T.M\ | << 1$. With T.M =10(ms), it must meet $|fd| << 100/\pi$ (=) 30(Hz). For RF frequency fr = 300MHz and the speed of the object 6000m/s, the Doppler frequency shift is 6,000Hz, far greater than the limit. Thus the PN correlation detection will be made in 10Hz steps.

[8] Configuration of Radar Station

The configuration of the proposed RADAR station is depicted in the following figure.



Configuration of RADAR station

3. Missiles Capturing System

3.1 Features of the proposed system

While the conventional defense missiles hit the offense missiles on orbits to destroy them, the herein proposed system does not hit but capture the targets nuclear war heads in space with greater certainty.

3.2. Operational Steps of the proposed missile defenses

[1] Initiation of defense

The satellites and long range RADAR systems measure and establish the orbits of the attacking warheads.

On detection of being attacked, the defense system initiates the following operations.

[2] Decision of the steps of defense

Step 1 Launch of defense missile

to ; Time of the launch

rd(to) ; Location vector of the missile base

ad(0); acceleration vector of the defense missile

Step 2 Capture the target

t1 ; Time of separation of the booster rockect

rd(t1) ; position of the missile at t1

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

ad(1) ; acceleration in step2

ta ; time to capture the target at;

Ra ; position of the missile at ta

Va ; velocity of the missile at ta

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

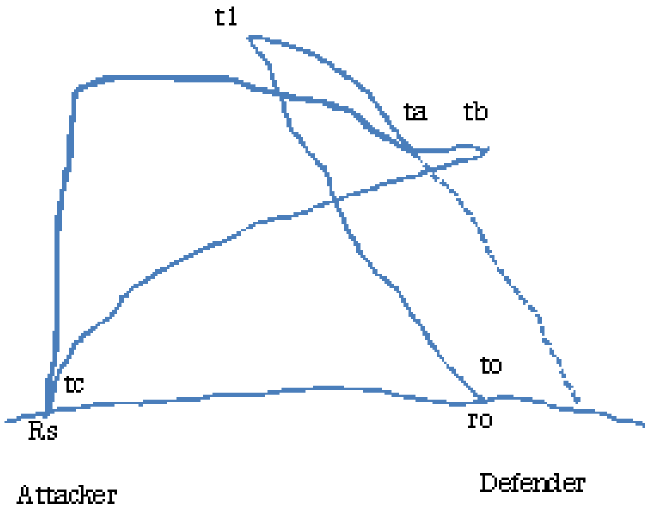
Step 4 Return the warhead to the sender

tc ; time to return the warhead to the sender

Rs ; positional vector of the sender's location

c ; acceleration vector in this step

The above operations are depicted in the following figure.



3.3 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 ad(0) is given;

$ad(0) = f / M – g$

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;

$vd(t1) = ad(0).(ti\text{-}to) = ad(0).Ti$

$rd(t1) = rd(to) + ad(0).Ti\text{^}2 / 2$

The energy consumed in this step is

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

$= M.(ad(0) +g).ad(0).Ti\text{^}2 / 2$

Step2 Capture the target

Let am' be the acceleration during this stage, then

The velocity at ta must be

$vd(ta) = vd(t1) + ad(1).(tf - t1) = Va$

The positional vector at ta must be ;

$rd(ta) = rd(t1) + ad(1).(ta - t1)\text{^}2/2 = Ra$

The above relations determine the required acceleration vectors ad(0) and ad(1) as follows;

$ad(1) = \{ 2(Ra - rd(to)) - Va.Ti \}$

$/ \{ (ta - to - Ti).(ta - to - 2Ti) \}$

$ad(0) = \{ Va.(ta– to – Ti) – 2(Ra – rd(to)) \}$

$/ \{ Ti.(ta – to – 2Ti) \}$

Let the thrusting force and mass of the missile in step 2 be f', M', then the acceleration ad(1) is given;

$f' / M' – g = ad(1)$

The energy consumed in step 2 is;

$E2 = [t1, ta] \int M' (ad(1) + g). (vd(t1) + ad(1).(t- t1))dt$

$= M' \cdot (ad(1) + g). (ta– to – Ti)$

$\cdot \{ ad(0).Ti + ad(1)(tf – to – Ti) / 2 \}$

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;

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

Where b is the acceleration vector in this step.

The position of the warhead and defense missile at tb is

$rj(tb) = Ra + Va(tb- ta) + b.(tb – ta)\text{^}2 /2$

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

$f" / M" - g = b$

The energy consumed in this step is

$E3 = [ta, tb] \int f". v(t)dt$

$= M" Va . (g.(tb- ta) - Va)$

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

Let Rs be the positional vector of the launcher.

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 c, then

$Rs = rj(tb) + c.(tc - tb)^2 /2$

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

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

$E4 = [tb, tc] \int f'''.vj(t).dt$

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

4. Defense against Cruise missiles

Cruise missiles are difficult to track by RADAR on the ground hence need to be detected and tracked by satellites. Their orbit is not accurately predictable hence the defense missile need to close in and capture the cruise missile. As the altitude is low a nuclear explosion can bring a disaster on the ground, it is essential to capture and carry it back to the launcher or carry it to some remote area or space to destroy it safely.

5. Notes on Satellites systems

The peace treaty of space has been recently neglected by some countries and illegal developments of attacking systems to destroy the satellites in orbits are accelerating. The low earth orbits (LEO) satellites are now easy prey for attacks from the ground. Therefore it will be safer to use the satellites in much higher orbits. The geostationary orbits (GEO) satellites are particularly suitable not only for their distances but also the wide coverage and capability of high speed communication links with the ground.

6. Conclusion

The proposed system which can immediately detect the launch, track the flight, determine the orbit of nuclear missiles and capture them with a certainty has been described. The satellites play important roles in the system for immediate detection of launch of nuclear missiles and especially in tracking the course of cruise missiles. The satellites, especially those in GEO can provide all time watching eyes on the ground and high data rates communication links to transfer the observation data. The nuclear warheads either in ICBM or cruise missiles can be captured, carried back to the launcher or away to some safe places to be destroyed.

Benefits of the proposed system are not limited to military but also for general safety operations against wild fires, monitoring and control of aircrafts over wide areas.

The author sincerely wishes that the proposed system will be developed and deployed widely to nullify the threats of nuclear weapons and promote safety of the world.

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