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A study on design of range reduction dummy fuze(RRDF)for the efficiency of acceptance test

2011. 10

Hae Suk Lee

Contents

- Background and Purpose

- A task for design of RRDF

- A stage for development

- A verification for trajectory

- Results

❑ Background and Purpose

A difficult for K9
assembly for
acceptance test

Fishing Boat

Sea Control

Civil Appeal

Manpower and Equipment

Test Schedule

Production Plan
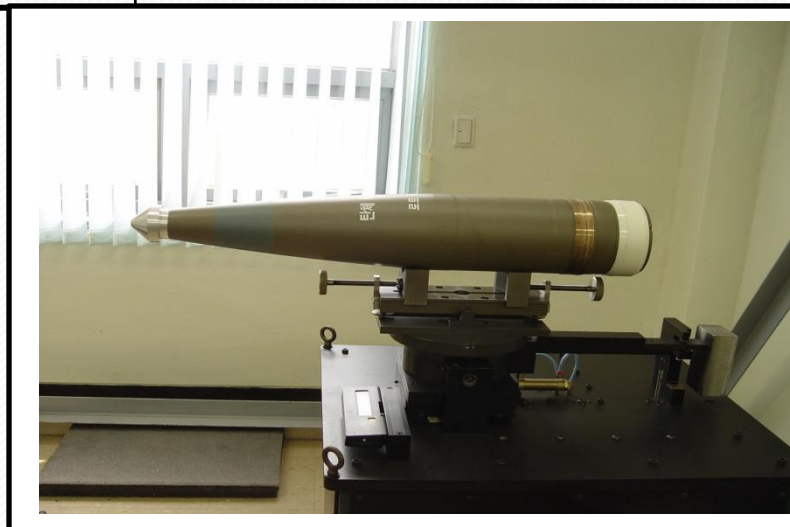
❏ Background and Purpose

- ▪ K9 Self-propelled howitzer

K9 Assembly

❑ Background and Purpose

- A content for K9 Acceptance test

Order	Elevation(mils)	Ammunition	Range for Safety
1	26	KM107/KM73A1/K677(U2)	1~6km
2	26	K309(BB ON)/K519/K678	3~17km
3	1208	K309(BB ON)/K519/K678	32~35km

K309 projectile with RRDF

❑ Background and Purpose

▪ A range for K9 safety range

Elevation(km)

25km

13km

6km
m

17km

34km

0
Firing Site

1st(26mils)

2nd(26mils)
3rd(1208mils)
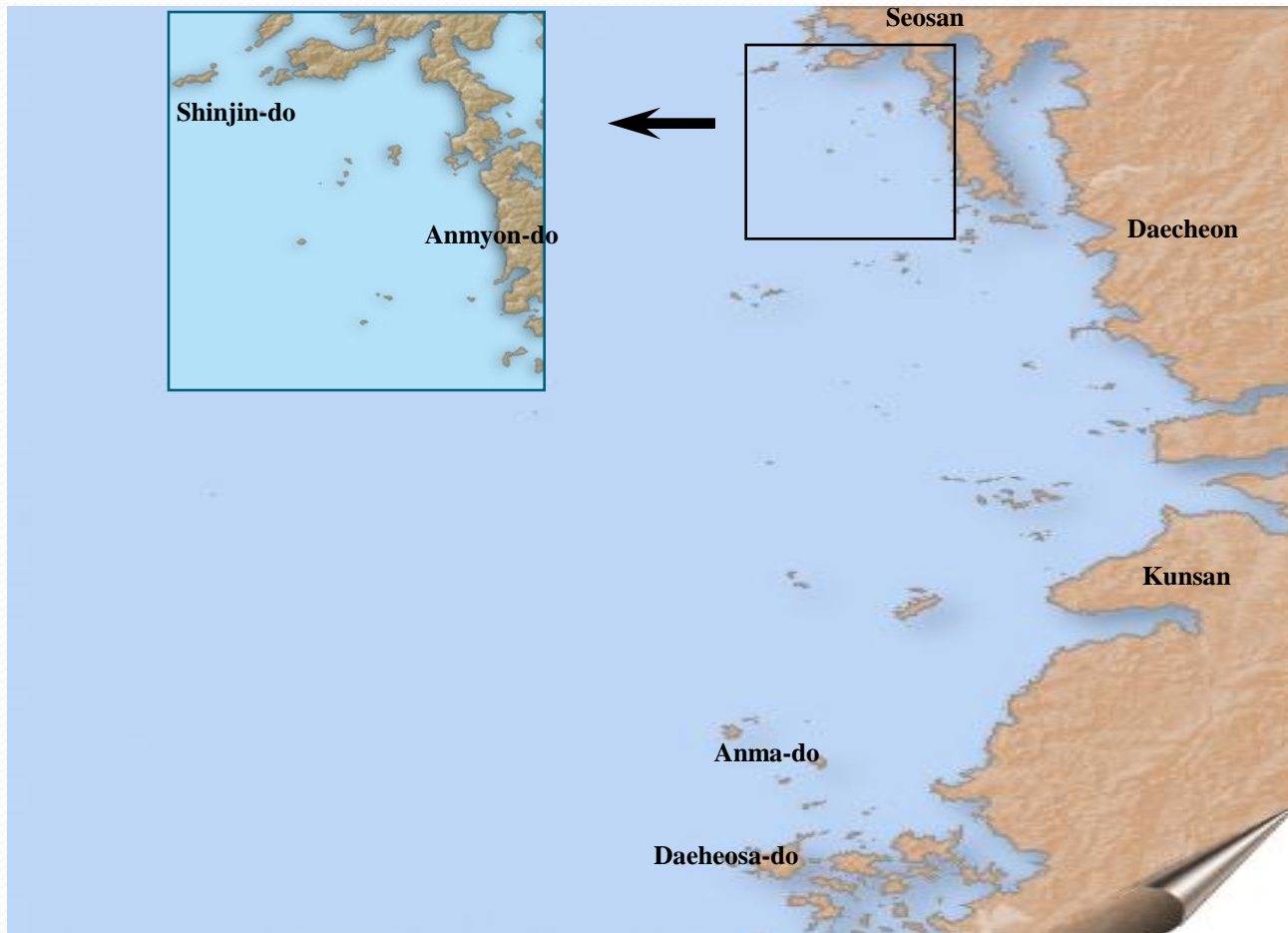
Range(km)
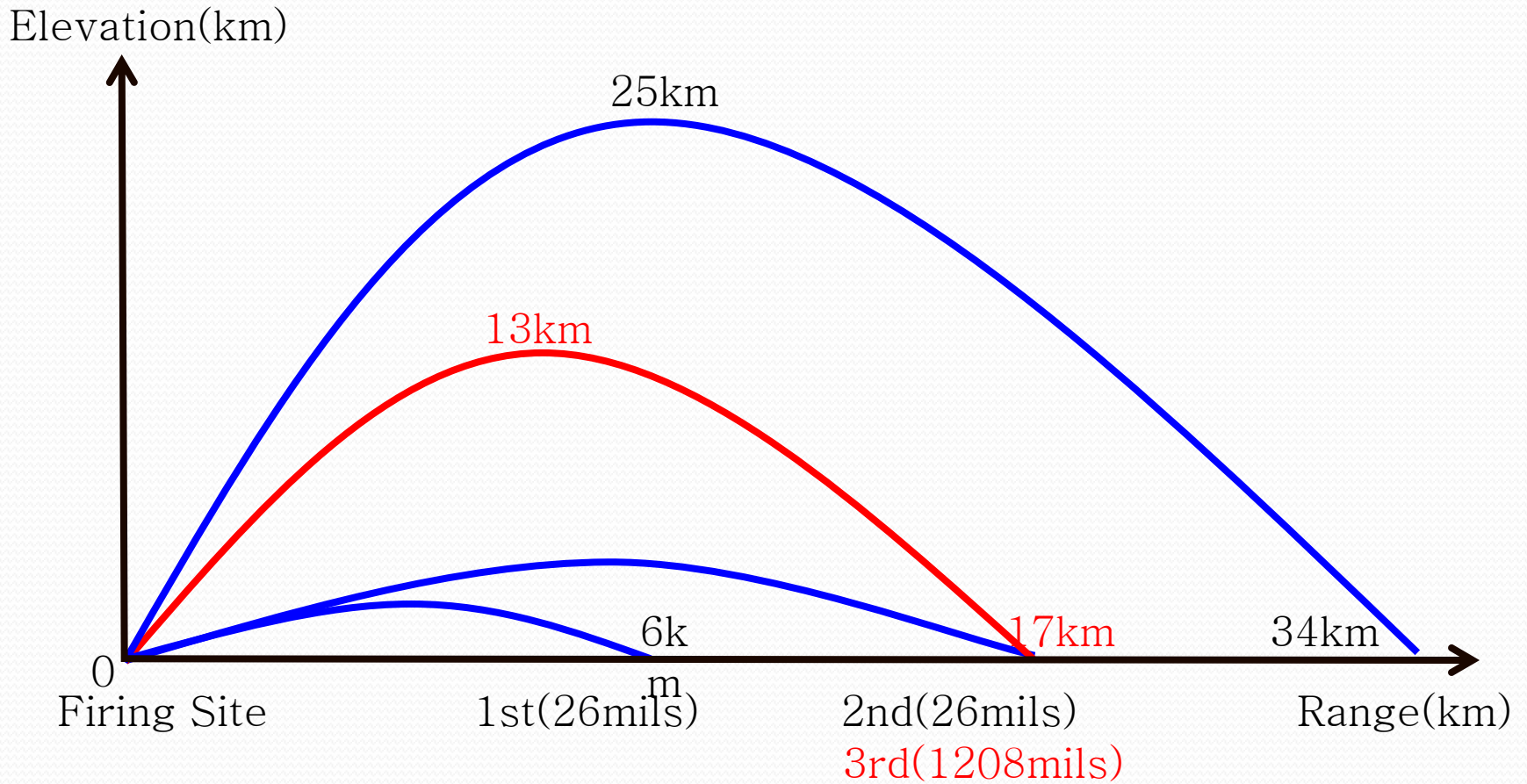
❑ Background and Purpose

- ▪ Firing Direction

❑ A task for design of RRDF

▪ A Technology for drag force increasing

❑ A task for design of RRDF

▪ Drag force coefficient

$$C_{D_0} = \boxed{C_{D_H}} + C_{D_{BT}} + C_{D_B} + C_{D_{RB}} + C_{D_{SF}}$$

$C_{D_0} = A\ total\ of\ drag\ force\ coefficient$

$C_{D_H} = A\ drag\ force\ coefficient\ by\ nose$

$C_{D_{BT}} = A\ drag\ force\ coefficient\ by\ boattail$
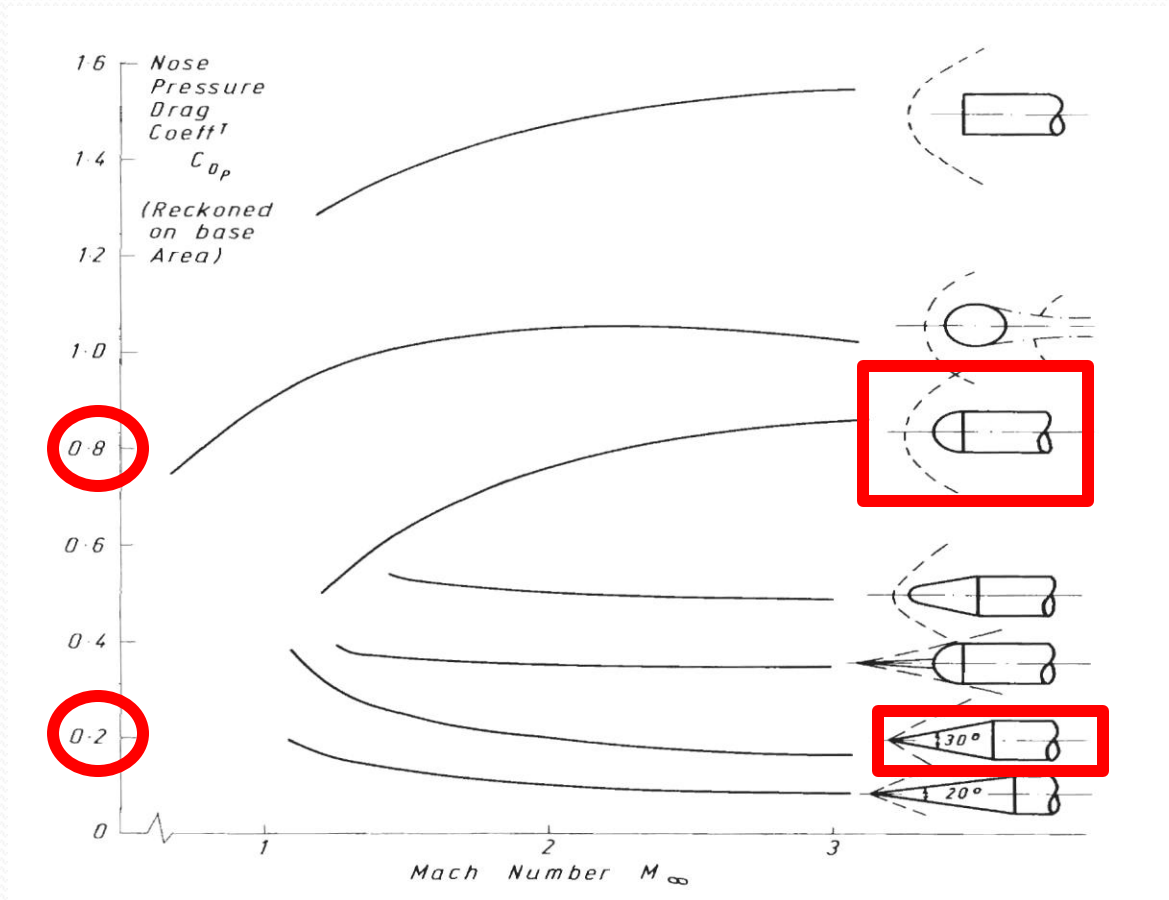
$C_{D_B} = A\ drag\ force\ coefficient\ by\ base$

$C_{D_{RB}} = A\ drag\ force\ coefficient\ by\ rotating\ band$

$C_{D_{SF}} = A\ drag\ force\ coefficient\ by\ skin\ friction$

＊Reference : Jae Hun Jung,"A Study for Drag force decreasing",
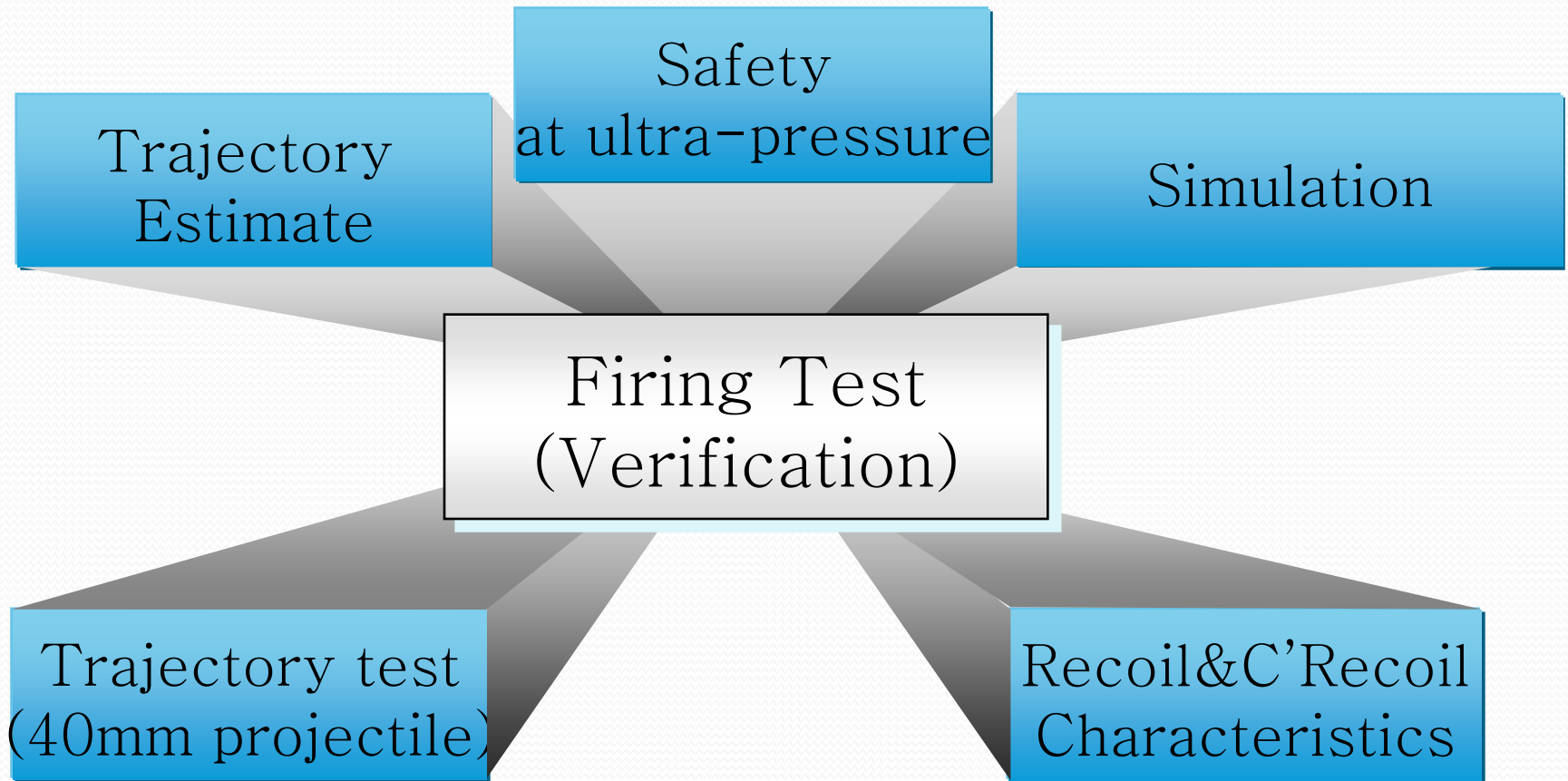Korea Military Academy, 2001(2~3page)

❑ A task for design of RRDF

- A drag force coefficient by warhead shape

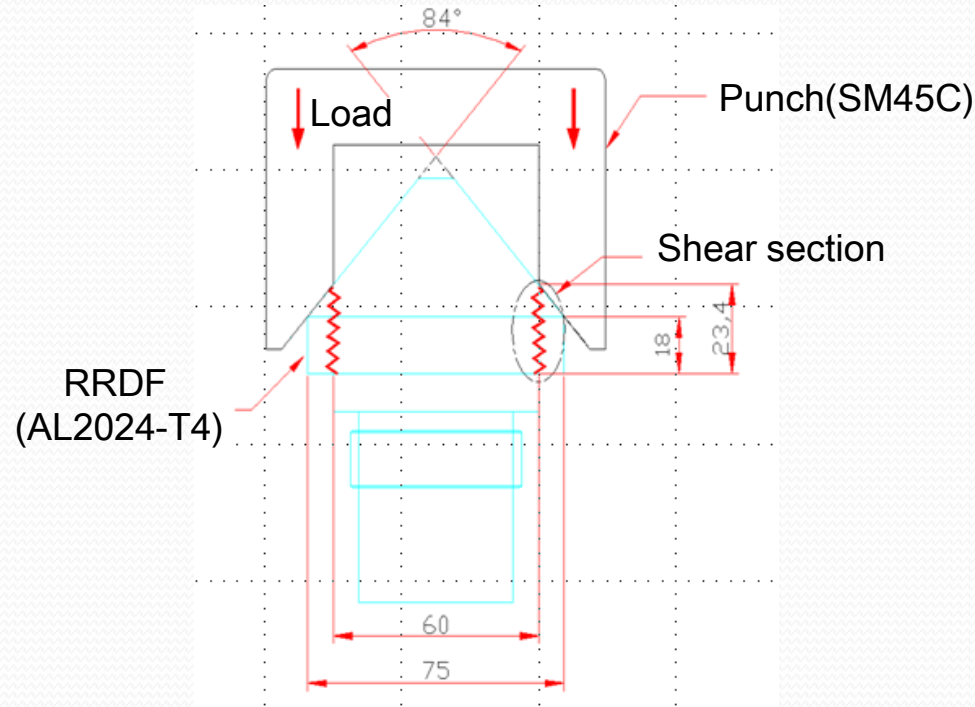＊ Refence : Guided Weapons(Brassey's Defense Publishers, 66page)
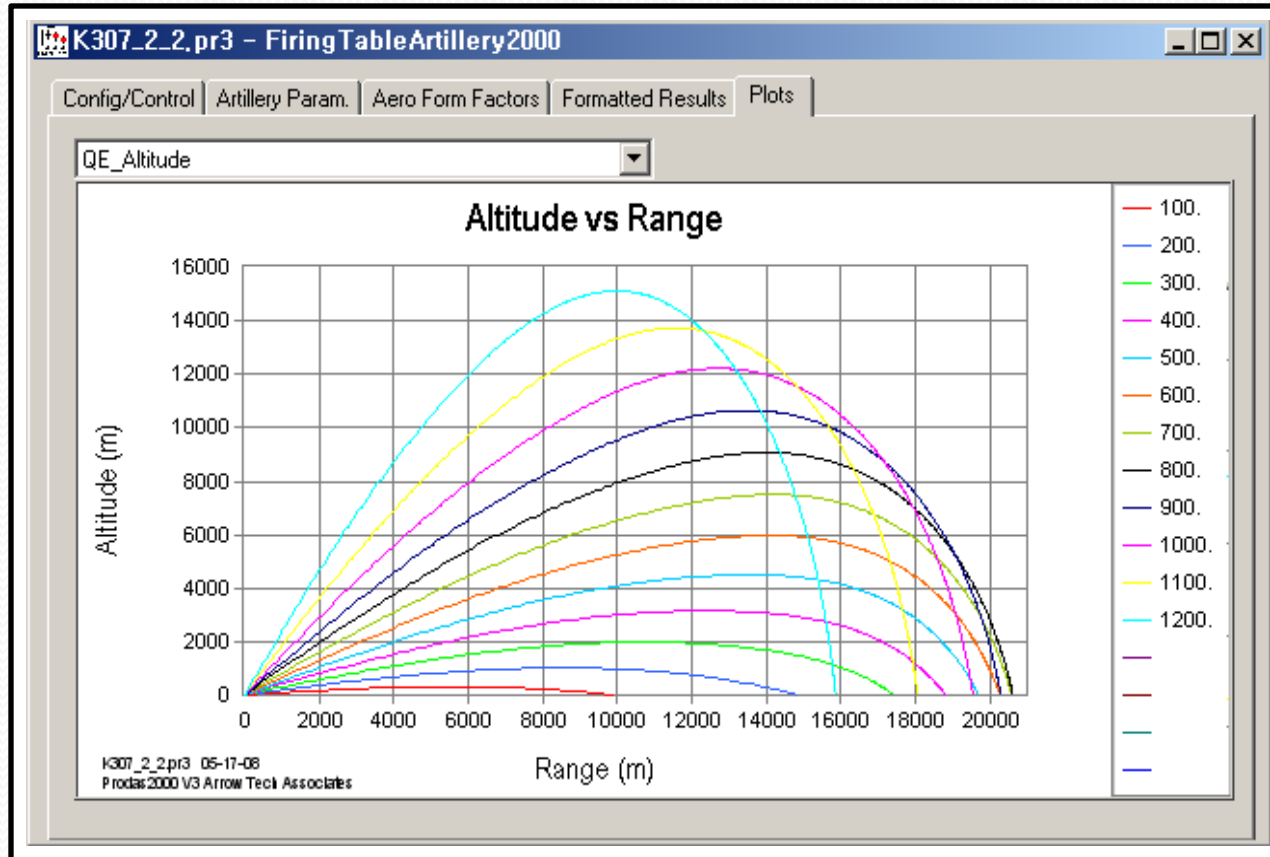
❑ A task for design of RRDF

Safety
at ultra-pressure

Trajectory
Estimate

Simulation

Firing Test
(Verification)

Trajectory test
(40mm projectile)

Recoil&C'Recoil
Characteristics

❑ A task for design of RRDF

- ▪ A safety for Ultra pressure(Static test)

Load

Punch(SM45C)

Shear section

RRDF
(AL2024-T4)

84°

18

23.4

60

75

$$P = \tau \times A_1 = \tau \times \pi d t$$
$$= 24.5 \times 3.14 \times 60 \times 23.4$$
$$= 108,009.7 \ kg$$
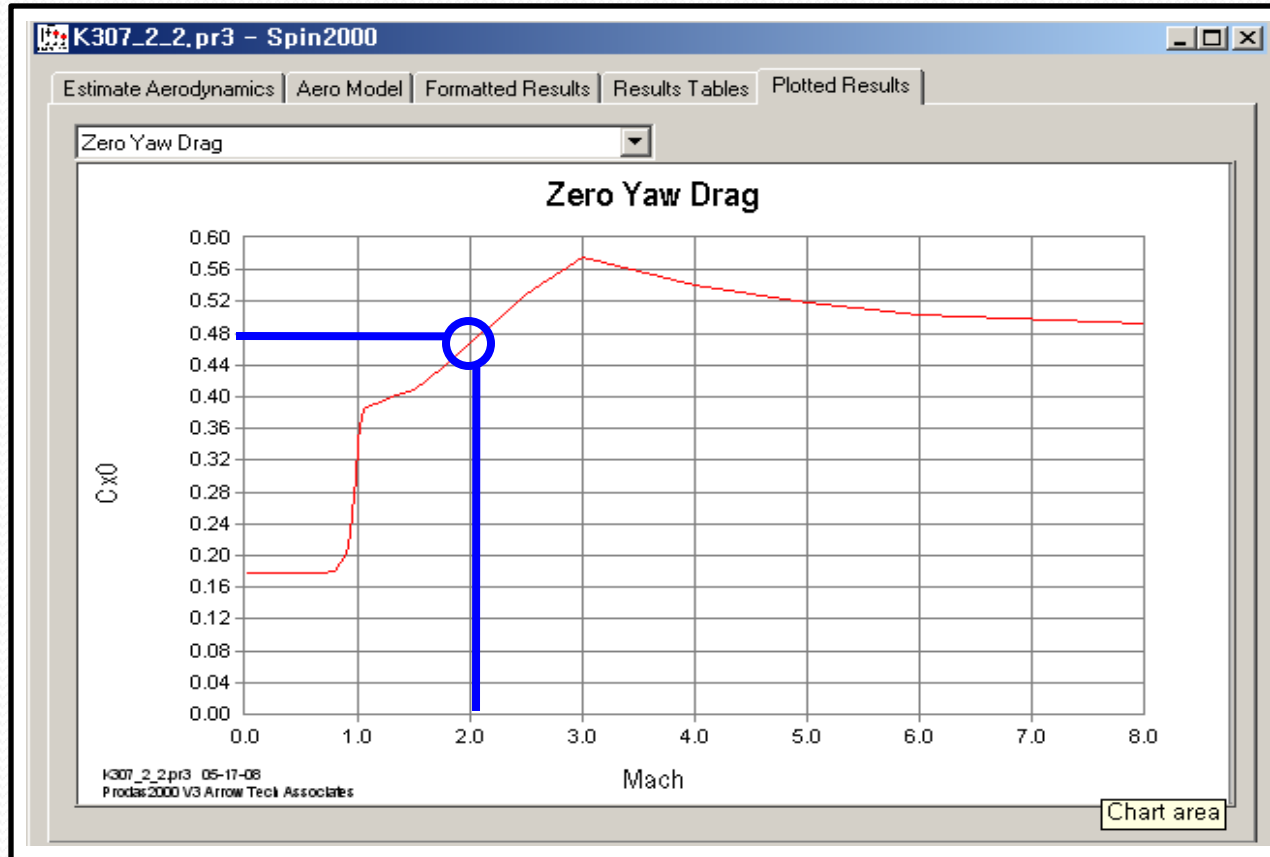$$= 108.01 \ ton$$
$$\tau = 24.5 \ (kg/mm^2)$$

❑ A task for design of RRDF

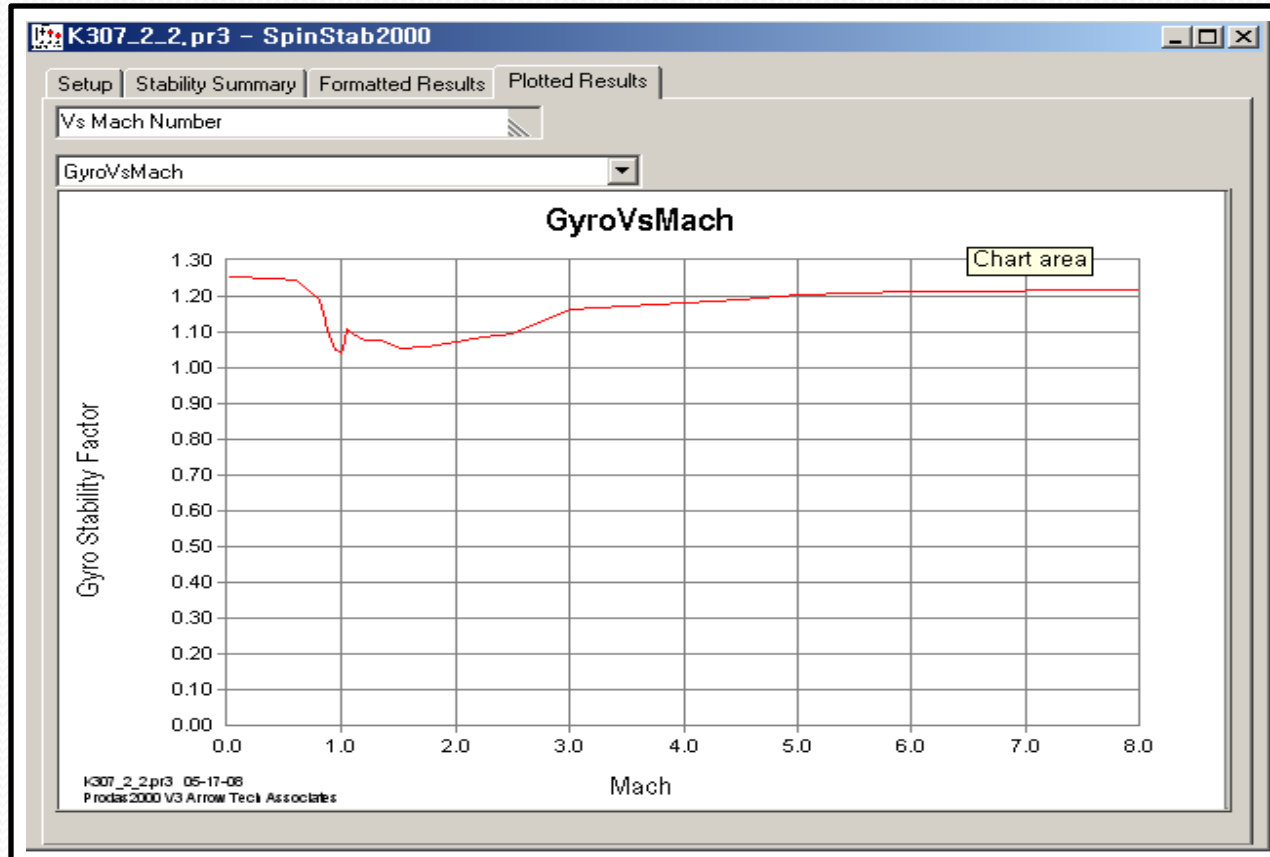▪ Trajectory estimate(Prodas V3)

❑ A task for design of RRDF
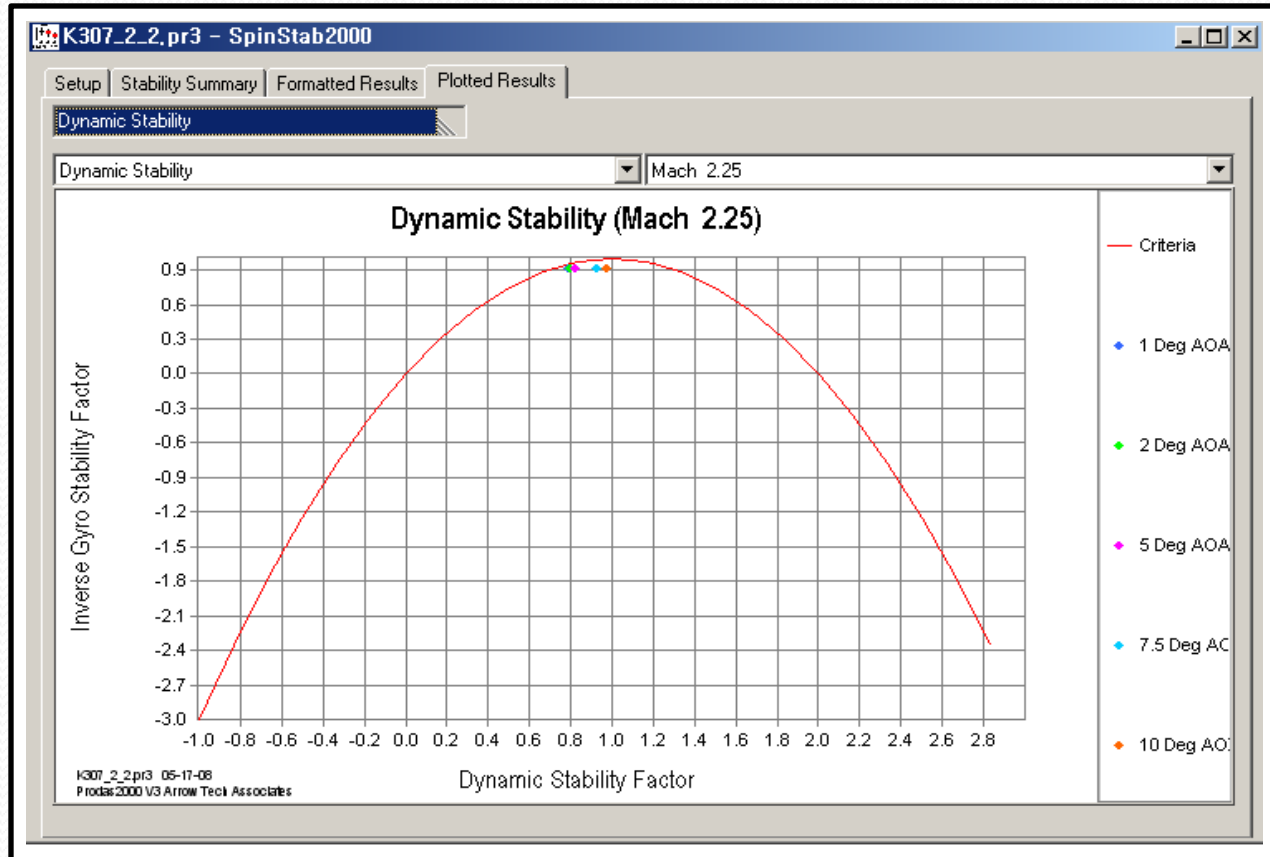
- ▪ Drag Coefficient estimate(Prodas V3)

❑ A task for design of RRDF

- Gyro Stability estimate(Prodas V3)

❑ A task for design of RRDF

▪ Gyro Stability and Dynamic Stability(Prodas V3)

Prodas V3 이용(Gyro Stability & Dynamic Stability)

❑ A task for design of RRDF

- ▪ Gyroscopic Stability & Dynamic Stability

$$S_g = \frac{I_{xx}^2 \, p^2}{2I_{yy}\rho A d V^2 C_{M\alpha}}$$

$$S_d = \frac{2[C_{N\alpha} - C_D + (md^2/2I_{xx})(C_{Mp\alpha}]}{C_{N\alpha} - 2C_D - (md^2/2I_{yy})(C_{Mq} + C_{M\alpha'})}$$

p^2 : $Rotating\ velocity\ of\ projectile$
$C_{M\alpha}$: $Overturn\ moment\ coefficient$
$C_{N\alpha}$: $Normal\ force\ coefficient$

$C_{Mp\alpha}$: $Magnus\ moment\ coefficient$
$C_{mq} + C_{M\alpha}$: $Diminishing\ moment\ coefficient$

＊ Reference : Kim jin suk"A study of aerodynamics characteristics of rotating projectiles", ADD, 1990(20~22pages)

❑ A task for design of RRDF

- ▪ Trajectory Simulation(Point Trajectory Program)

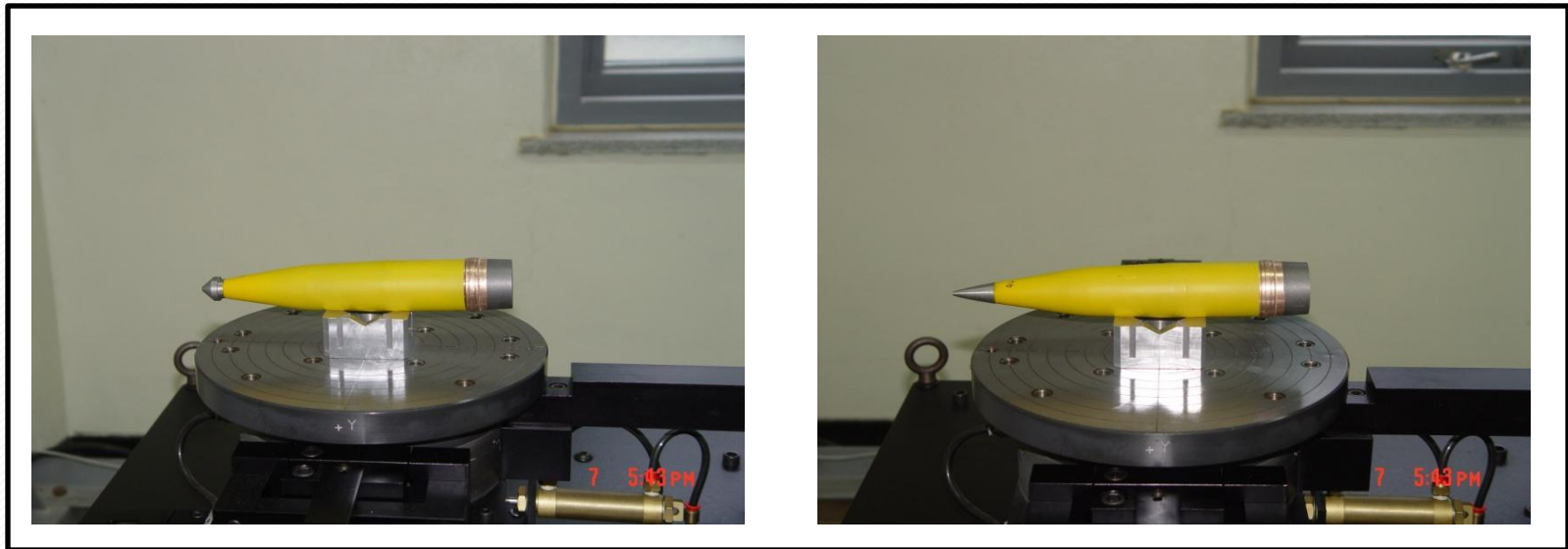A Range Estimate with point trajectory program

❑ A task for design of RRDF

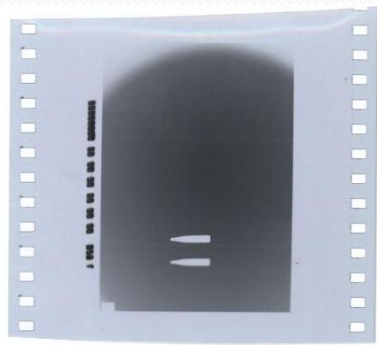▪ Trajectory Test(Downsized projectiles : 40mm)

❑ A task for design of RRDF

- ▪ **Trajectory Test(Downsized projectiles : 40mm)**

A measurement for Physical Properties

❑ A task for design of RRDF

- **Trajectory Test(Downsized projectiles : 40mm)**

  - A muzzle velocity

Reduces RRDF

order \ model	Reduced RRDF(m/s)	Reduced K519 fuze(m/s)
1	309.1	328.7
2	315.0	321.5
3	254.1	283.0
4	251.8	265.8
5	261.4	247.2
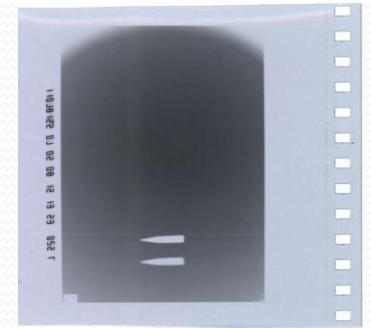
Downsized K519 fuze

  - Physical Properties

Properties \ model	Reduced RRDF	Reduced K519 fuze
Weight(g)	1092.5	1085.5
Axial MOI(g-cm^2)	2575.1	2514.1
Transverse MOI(g-cm^2)	38024.7	37435.5
CG from Nose(mm)	142.9	154.2

❑ A task for design of RRDF

▪ **Trajectory Test(Downsized projectiles : 40mm)**

➤ Aerodynamic and Sg (6-DOF Single Fit Analysis)

Model	Mach No.	C_{x0}	$C_{n\alpha x0}$	$C_{m\alpha}$	C_{mq}	$C_{np\alpha}$	S_g
Downsized RRDF	0.880	0.274	2.395	3.070	-10.6	-1.57	1.613
	0.898	0.278	2.557	3.243	-10.0	-2.40	1.586
	0.728	0.271	2.155	2.829	-10.0	-1.88	1.646
	0.721	0.268	2.229	2.786	-10.0	-1.93	1.626
	0.749	0.271	2.163	3.073	-10.0	-1.69	1.734
Downsized K519	0.941	0.206	2.250	3.233	-21.3	-3.25	1.687
	0.921	0.196	1.997	2.931	-20.3	-1.91	1.688
	0.811	0.183	2.058	2.348	-15.2	-2.56	2.002
	0.766	0.188	2.109	2.386	-15.0	-2.94	1.954
	0.711	0.182	2.174	2.114	-13.8	-1.19	1.926

❑ A task for design of RRDF

- ▪ Trajectory Test(Downsized projectiles : 40mm)
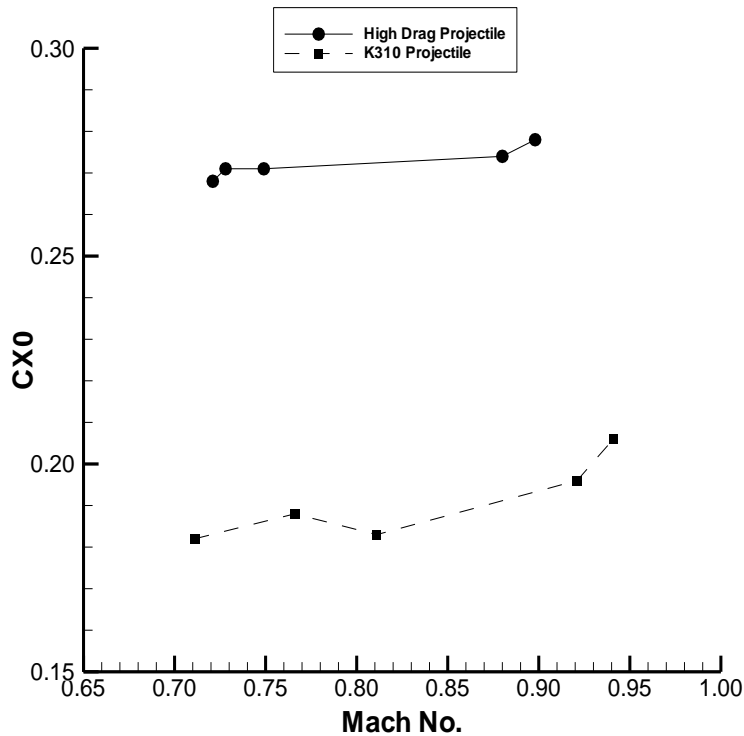
Drag Coefficient, CXO Comparison
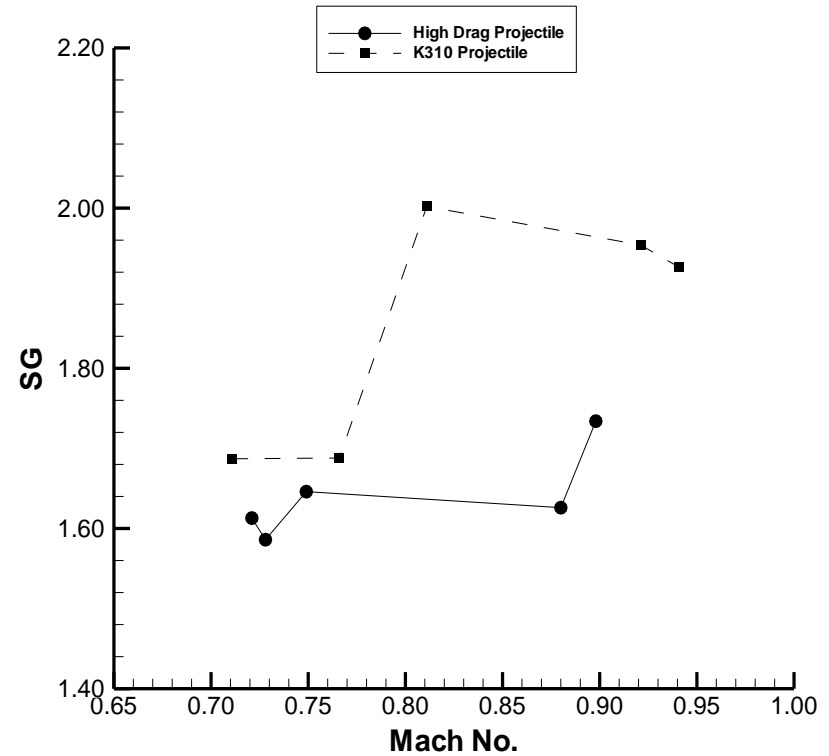
Gyroscopic Stability Factor, SG Comparison

❑ A task for design of RRDF

▪ 155mm K9 Recoil & C'Recoil characteristics
   (Recoil Length, 1Cycle time, C'Recoil velocity, Internal pressure)

LVDT(Installation)

LVDT : Linear variable Differential transformer

Elevation(1208 mil)

| LVDT Sensor | → | Signal Conditioner | → | A/D Converter | → | Data/Report |

❑ A task for design of RRDF(Comparison)

Section	RRDF	K519 Dummy	Plate Fuze
Figure			
Weight	715±15g	715±15g	975g ±25g
Material	AL A2024T4-T4 (KS-D-6763)	AL A2024T4-T4 (KS-D-6763)	SCM30 (KS-D-3752)
Length	125mm	167mm	60mm

❑ A task for design of RRDF

▪ RRDF

=== SPACE ELECTRONICS, INC. ===
KSR150K-185 Mass Properties System

```
   Operator :  lee choon sik
       Date :  MAY 27, 2005
       Time :  11:49:50
Part Serial :  307/Rfuze
    Part Id :  1
   Comments :  CG

Test Number :  10818
```

Center of Gravity Plot Viewed From Above Machin
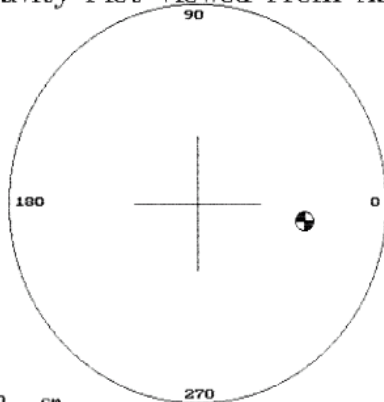

```
FULL SCALE: 0.5000   cm
User Angles inside circle
Machine Angles outside circle
```

```
Machine Referenced CG              User Referenced CG ( USER ANGLE )

  0 Offset:      0.284502 cm         0 Offset:      0.284502 cm
 90 Offset:     -0.044848 cm        90 Offset:     -0.044848 cm
 Magnitude:      0.288015 cm        Magnitude:      0.288015 cm
     Angle:   351.04°                   Angle:   351.04°
```

▪ K519 Dummy fuze

=== SPACE ELECTRONICS, INC. ===
KSR150K-185 Mass Properties System

```
   Operator :  lee choon sik
       Date :  MAY 27, 2005
       Time :  11:32:51
Part Serial :  307/519
    Part Id :  1
   Comments :  CG

Test Number :  10815
```

Center of Gravity Plot Viewed From Above Machin


```
FULL SCALE: 0.5000   cm
User Angles inside circle
Machine Angles outside circle
```

```
Machine Referenced CG              User Referenced CG ( USER ANGLE )

  0 Offset:      0.273951 cm         0 Offset:      0.273951 cm
 90 Offset:     -0.044841 cm        90 Offset:     -0.044841 cm
 Magnitude:      0.277597 cm        Magnitude:      0.277597 cm
     Angle:   350.70°                   Angle:   350.70°
```
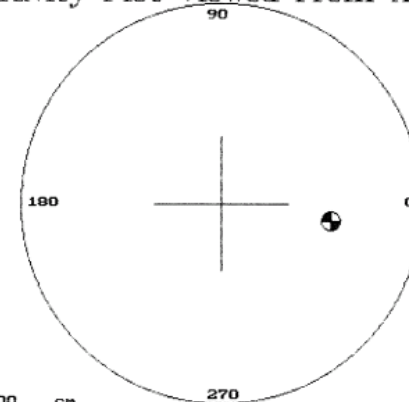
(A center of weight)

❑ A task for design of RRDF

▪ RRDF

=== SPACE ELECTRONICS, INC. ===
KSR150K-185 Mass Properties System

Operator : lee choon sik
Date : MAY 27, 2005
Time : 11:49:50
Part Serial : 307/Rfuze
Part Id : 1
Comments : CG

Test Number : 10818

CALCULATIONS

Raw Measurement Information

CG   PART-DATE: MAY 27, 2005   TIME: 11:42:40   TEST NUMBER: 10817
CG   TARE-DATE: MAY 27, 2005   TIME: 11:06:25   TEST NUMBER: 10810
MOI PART-DATE: MAY 27, 2005   TIME: 11:37:39   TEST NUMBER: 10816
MOI TARE-DATE: MAY 27, 2005   TIME: 11:03:20   TEST NUMBER: 10809

Dimensional Information

Test Part Weight: 46.3960 kg   CG Height: 15.0000 cm

Part 0°=Machine   0.00°   Part 90°=Machine   90.00°

Center of Gravity

   Machine Referenced CG   User Referenced CG (USER ANGLE)

      0 Offset: 0.284502 cm   0 Offset: 0.284502 cm
     90 Offset: -0.044848 cm   90 Offset: -0.044848 cm
     Magnitude: 0.288015 cm   Magnitude: 0.288015 cm
        Angle: 351.04°   Angle: 351.04°

Moment of Inertia

Through Center of Table   Through Center of Gravity
   23064.49427 kg-cm Sq.   23060.64558 kg-cm Sq.

▪ K519 Dummy fuze

=== SPACE ELECTRONICS, INC. ===
KSR150K-185 Mass Properties System

Operator : lee choon sik
Date : MAY 27, 2005
Time : 11:32:51
Part Serial : 307/519
Part Id : 1
Comments : CG

Test Number : 10815

CALCULATIONS

Raw Measurement Information

CG   PART-DATE: MAY 27, 2005   TIME: 11:24:46   TEST NUMBER: 10814
CG   TARE-DATE: MAY 27, 2005   TIME: 11:06:25   TEST NUMBER: 10810
MOI PART-DATE: MAY 27, 2005   TIME: 11:21:27   TEST NUMBER: 10813
MOI TARE-DATE: MAY 27, 2005   TIME: 11:03:20   TEST NUMBER: 10809

Dimensional Information

Test Part Weight: 46.3940 kg   CG Height: 15.0000 cm

Part 0°=Machine   0.00°   Part 90°=Machine   90.00°

Center of Gravity

   Machine Referenced CG   User Referenced CG (USER ANGLE)

      0 Offset: 0.273951 cm   0 Offset: 0.273951 cm
     90 Offset: -0.044841 cm   90 Offset: -0.044841 cm
     Magnitude: 0.277597 cm   Magnitude: 0.277597 cm
        Angle: 350.70°   Angle: 350.70°

Moment of Inertia

Through Center of Table   Through Center of Gravity
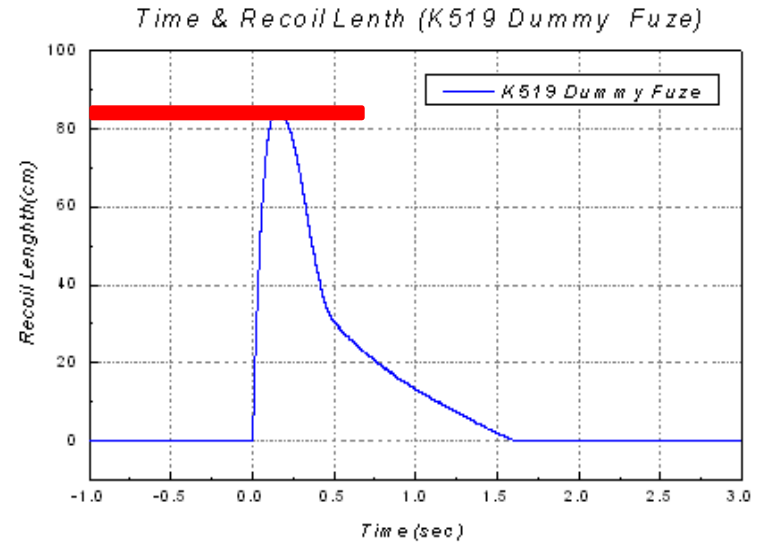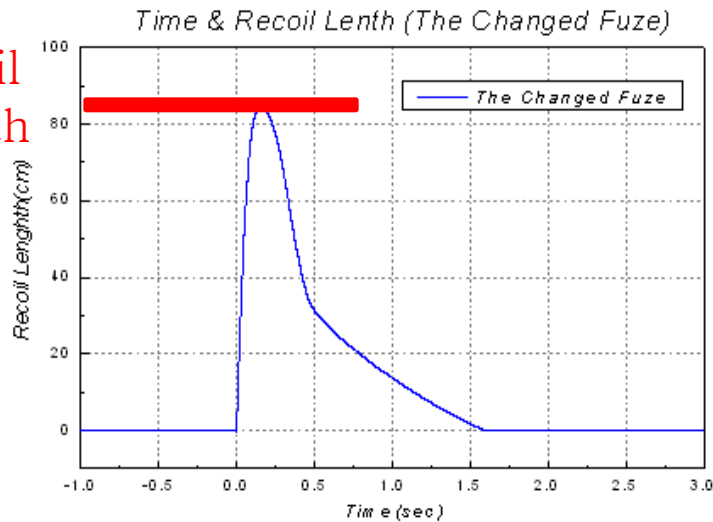   23022.15234 kg-cm Sq.   23018.57722 kg-cm Sq.

(A inertia moment)

❑ A task for design of RRDF
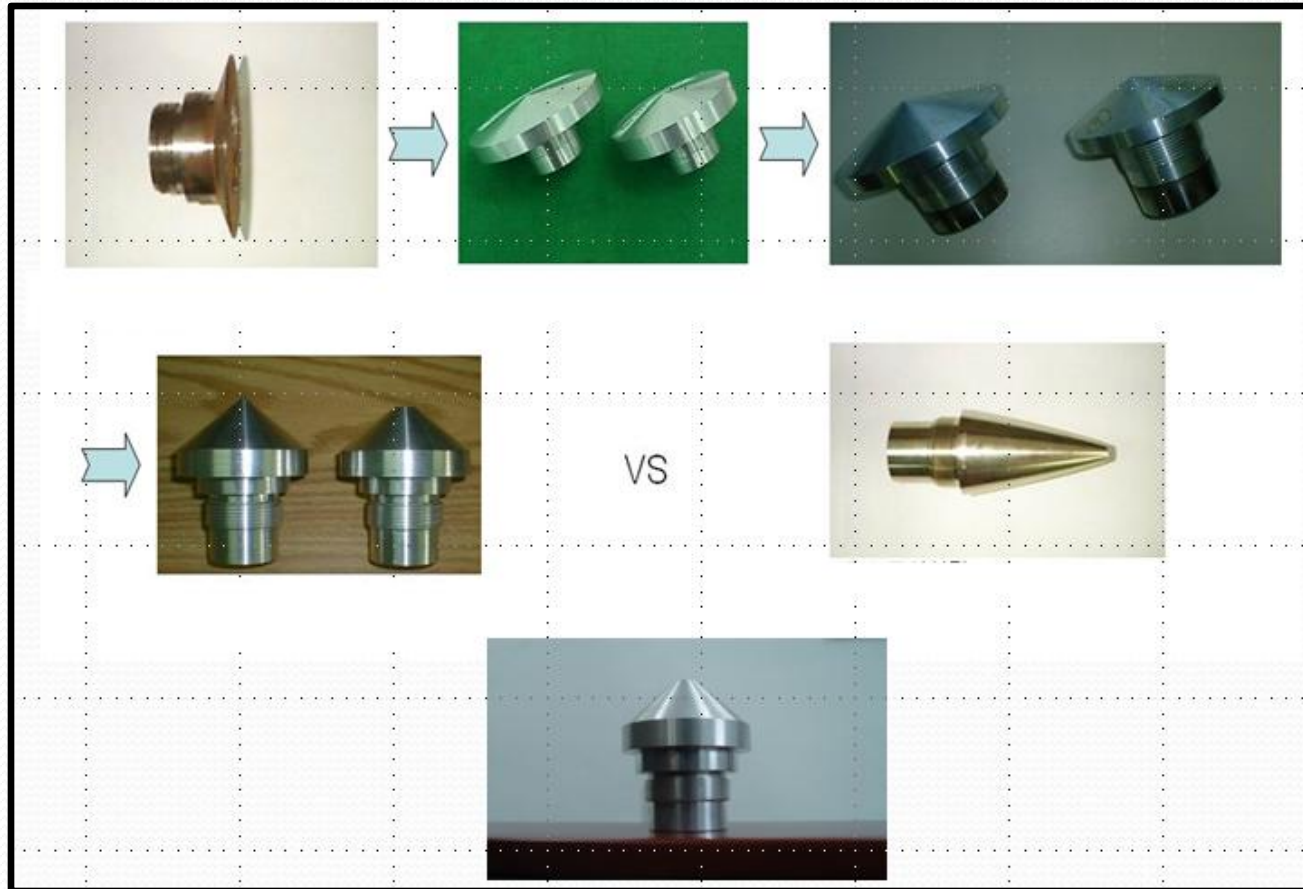(Recoil Length, 1Cycle time, C'Recoil velocity, Internal pressure)

❑ A task for design of RRDF

▪ (Recoil Length, 1Cycle time, C'Recoil velocity, Internal pressure)

Division	K519 Dummy Fuze			RRDF(Range Reducing Dummy Fuze)		
	Quantity	Average	Standard deviation	Quantity	Average	Standard deviation
Velocity	6	953.6	2.10	10	953.6	1.80
Internal pressure	6	64,800	780	10	63,820	900
Recoil Length	6	844	1.28	10	846	0.94
1cycle time	6	1.61 ①1.61 ⑤1.56	0.03	10	1.55 ①1.59 ⑩1.53	0.02
Counter Recoil Velocity	6	20	1.07	10	21	1.17

❑ A stage for development

❑ A stage for development

Graph: Test data; polynomial Regression
$Y = A + B1*X + B2*X^2$
$A = -25.9304$
$B1 = 1.41322$
$B2 = -0.01138$
$R\text{-Square} = 0.97164$

X-axis: Cordinated Fuze size(mm)
Y-axis: Firing Range(km)
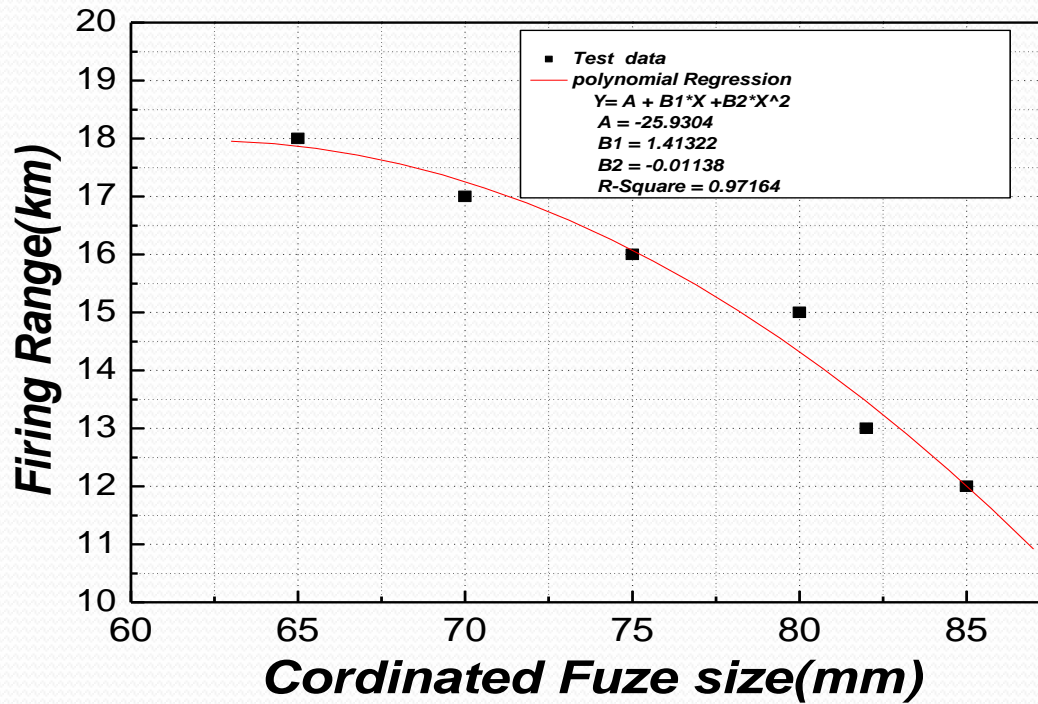
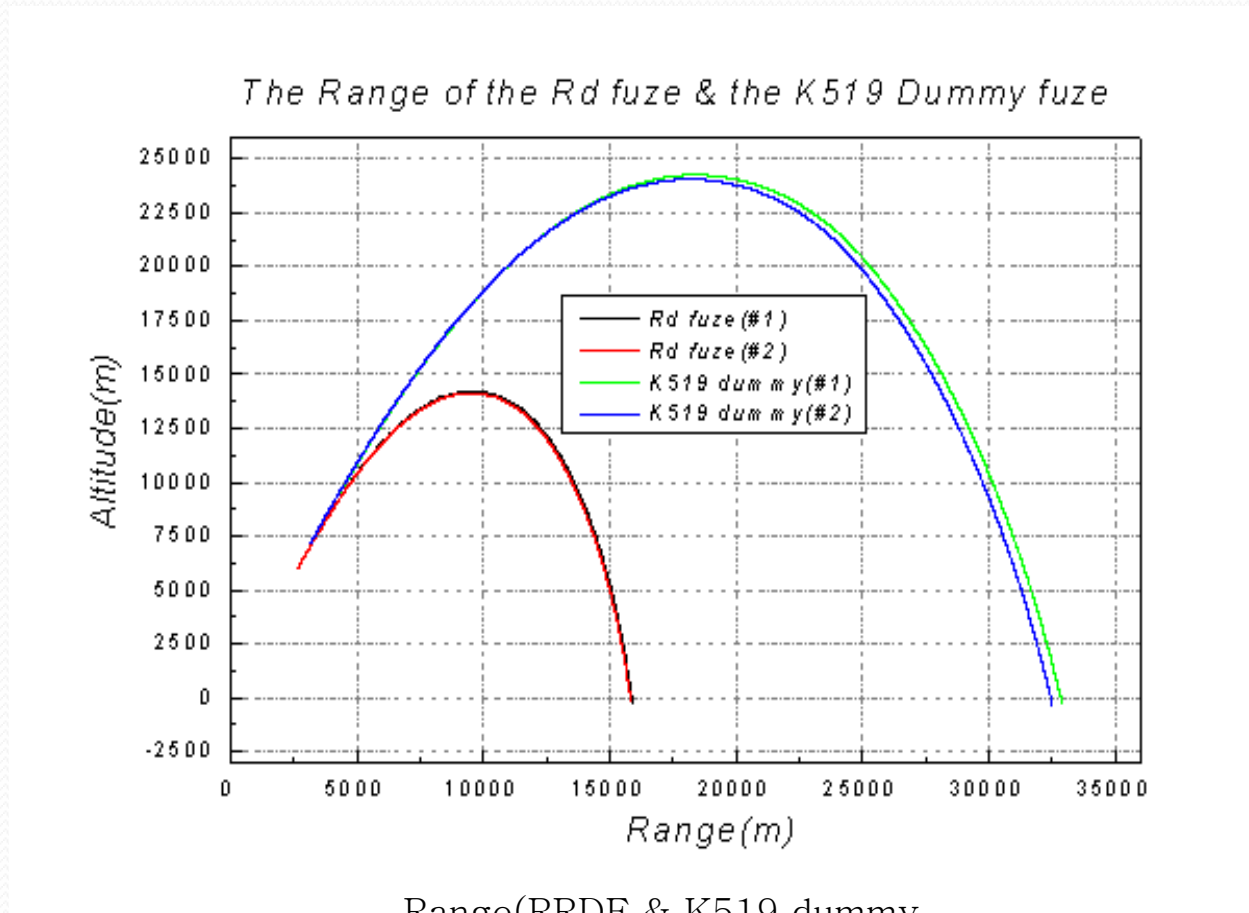| RRDF dia.(mm)	65	70	75	80	82	85	90
Range Estimate(km)	18	17	16	15	13	12	9.1

❑ A verification for trajectory
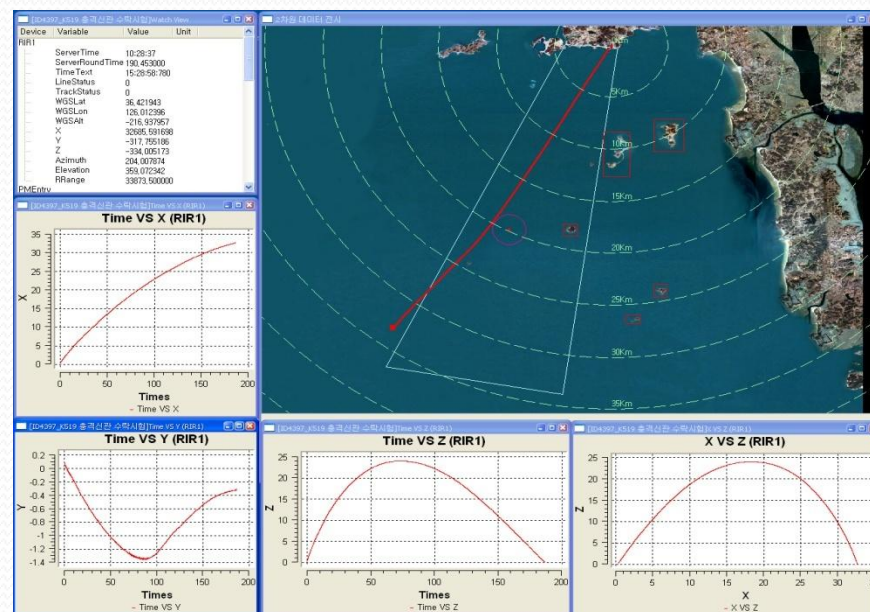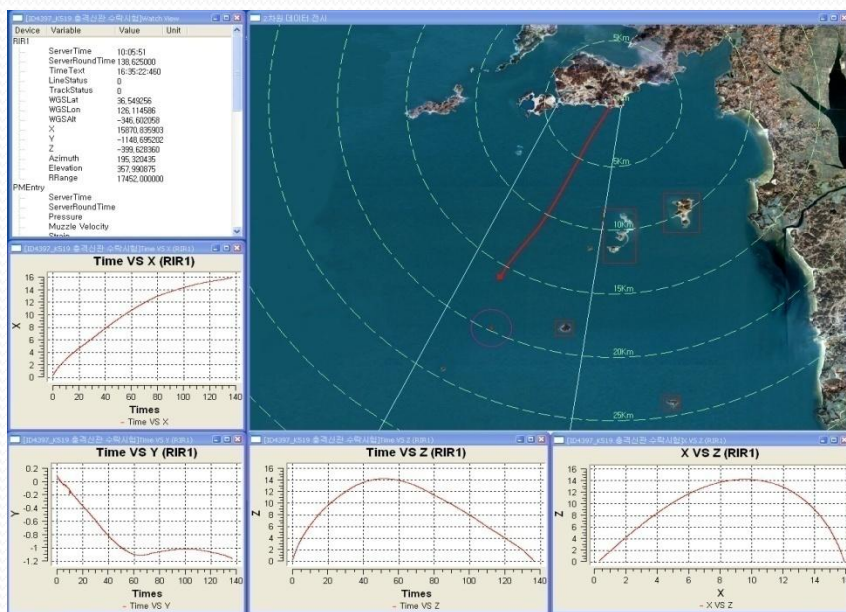
Moving Route(RRDF & K519 dummy fuze)

❑ A verification for trajectory(Range)

The Range of the Rd fuze & the K519 Dummy fuze

Range(RRDF & K519 dummy fuze)

❑ A verification for trajectory

- ▪ A distribution of range

Division	RRDF	155mm K309 projectile (K519 fuze)	Remarks
Average Range (Deviation)	15,896.3m (60.56m)	32,957.7m (425.4m)	elevation (1208mil) K678charge
Deflection	−119.2m (37.51m)	−2,522m (77.21m)	
Probable Error	0.255%	0.896%	

❑ A verification for trajectory

- Drag force Coefficient measurement(Doppler Rader : ED 6500)
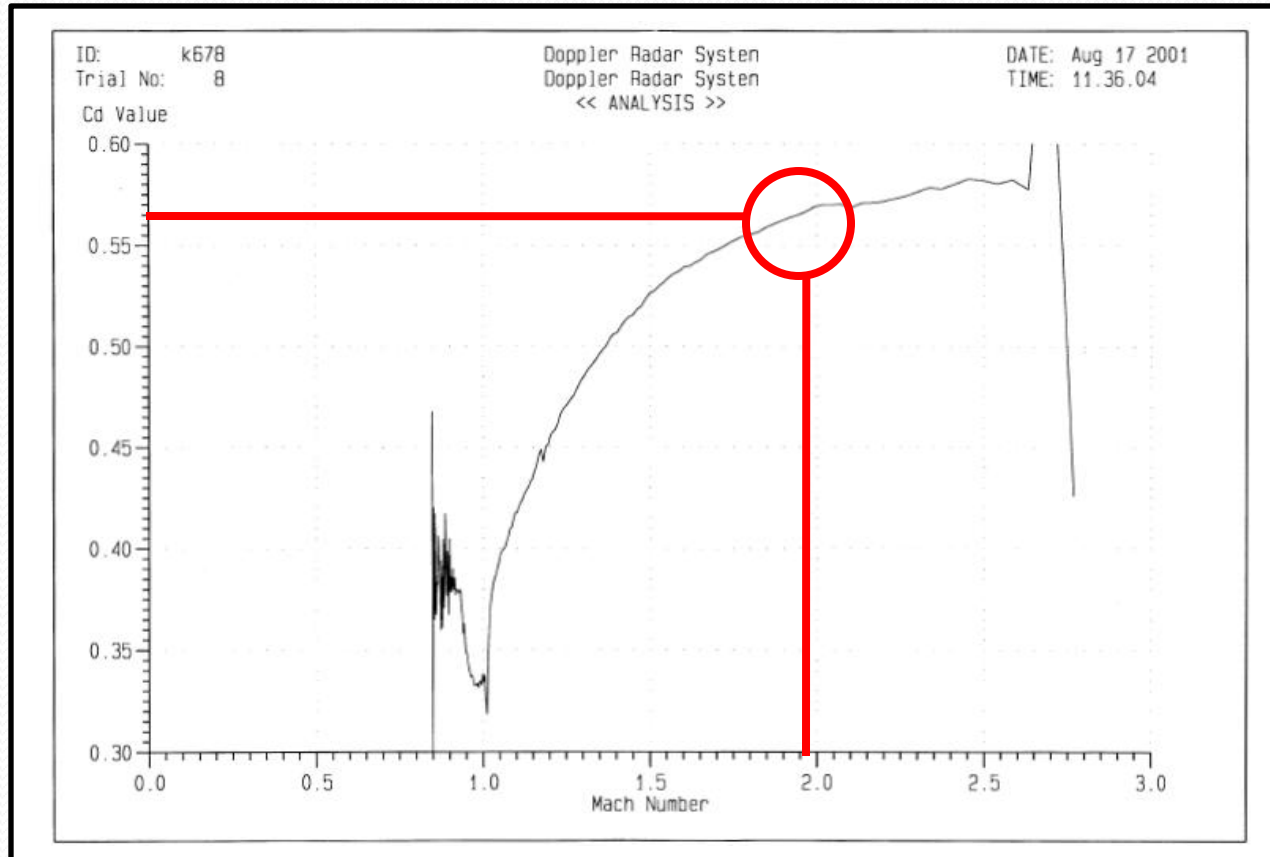
❑ Results

- We were able to study a RRDF which could reduce the range from 32km to 16km as 50%

- This will enhance the test efficiency and a oil fee which is used for safety ship also will be reduced

- At the elevation of 1208mils for K9 self propelled howitzer, A internal pressure, Recoil Length and recoil & Counter recoil were satisfied with the defense specification

- We simulated trajectory, preliminary range, trajectory stability and Drag coefficient with PRODAS

- We also tested RRDF with downsized projectiles and also studied projectile with full model

- By designed RRDF, Recoil & Counter Recoil characteristics, Muzzle velocity, Internal max pressures were proved an identity K519 fuze adapted to 155mm K309(BB ON)projectile

Thanks for you