

Our procedure to create
Fire Control Inputs (FCI) and Tabular Fire Tables (TFT)
for Howitzers & Mortars

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FCI & TFT Creation Capabilities and Fire Control Software

Fire Control Input (FCI) Creation

Preparation of input files (FCI) used by the fire control computer (AKB) during computer-aided firing with a weapon system for all kinds of heavy weapons and ammunition duos

- *Howitzer*
- *Mortar*
- *Tank*

Tabular Firing Table (TFT) Creation

Preparation of Tabular Firing Tables (TFT) for all kinds of heavy weapons and ammunition duos

- *Howitzer*
- *Mortar*
- *Tank*

Ability to use Fire Control Software

- *NABK-based fire control software*
- *EDABK-based fire control software*

Firing Test Capabilities

Planning

- *Defining necessary data to be gathered during firing tests*
- *Defining necessary instruments and their use*
- *Defining the number of rounds and the number of projectiles*
- *Defining quadrant elevation, azimuth angle, and propellant temperature ranges*

Support & Consultancy

- *Participating in firing tests as an observer and adviser*

FCI & TFT Creation

Determination of Project Stages

The number of stages and their contents are determined depending on the requirements defined in SOW and the parameters affecting them.

Requirements :

- *Sufficient information about weapon and ammunition*
- *Existing FCI files for ammunition and weapon and the conditions for the preparation of these files (if any)*
- *Actual fire test results for existing ammunition and weapon (if any)*

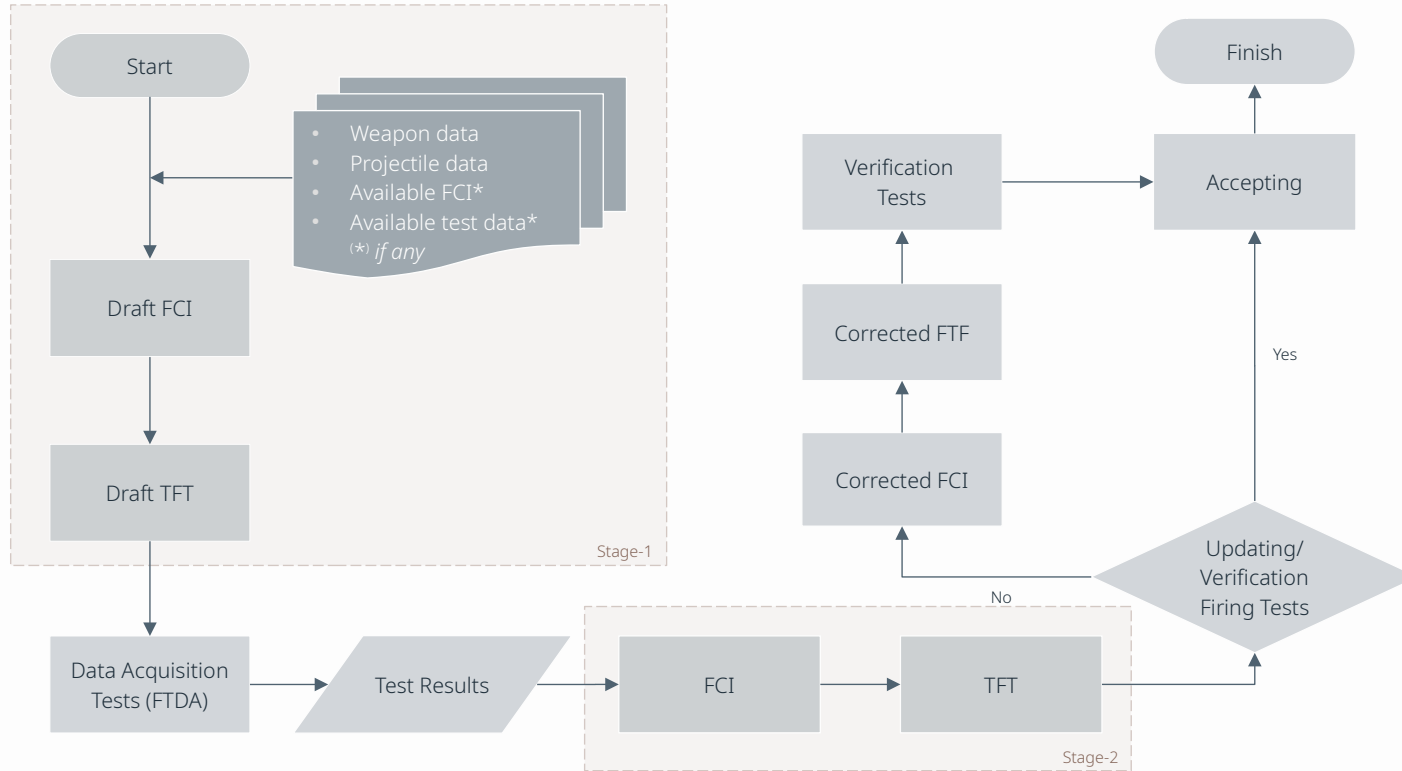
Parameters for Requirements :

- *Difficulty level of engineering problem*
- *Technical uncertainties*
- *Expected performance and acceptance criteria limitations*

Project Stages

<p>Stage-1 Preparation of Draft FCI & TFT</p>	Examining the source documents and input information to decide their adequacy
	Determining the methods to be applied
	Planning R&D studies if necessary
	Planning firing test for data acquisition (FTDA) and determining number of necessary number of rounds and shots and conditions
Firing Tests for Data Acquisition (FTDA)	
<p>Stage-2 Development of FCI & TFT</p>	Evaluation of results of the FTDA
	Updating Drafts and Developing FCI & TFT
Firing Tests for Verification and Acceptance (FTVA)	

Creation Process

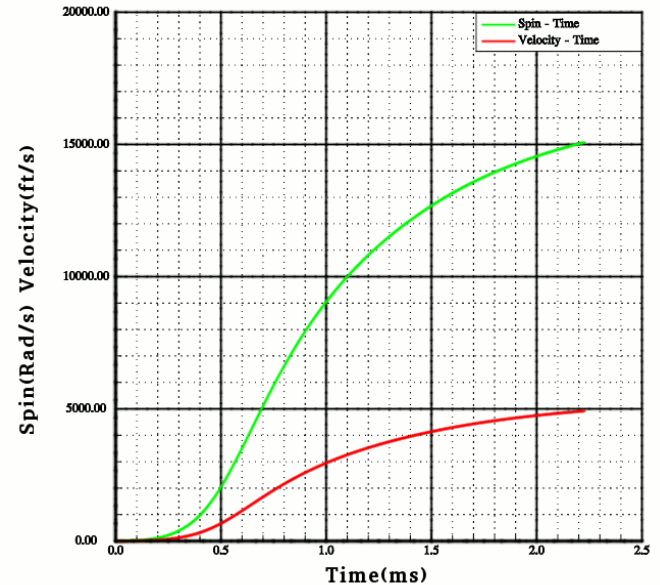
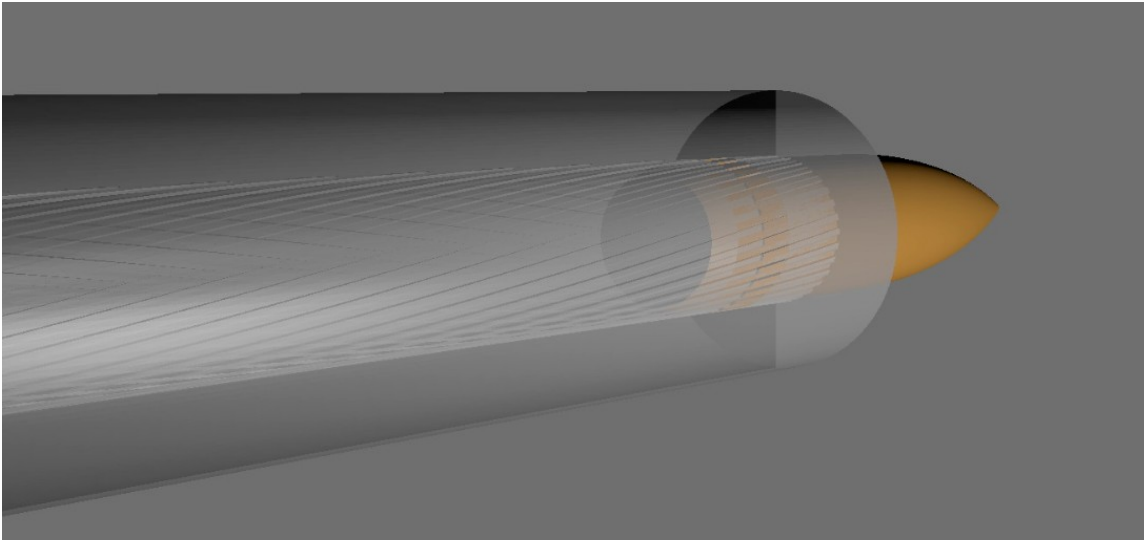


Our Procedure

Stage-1 : Preparation of Draft FCI & TFT

Internal Ballistic Calculations

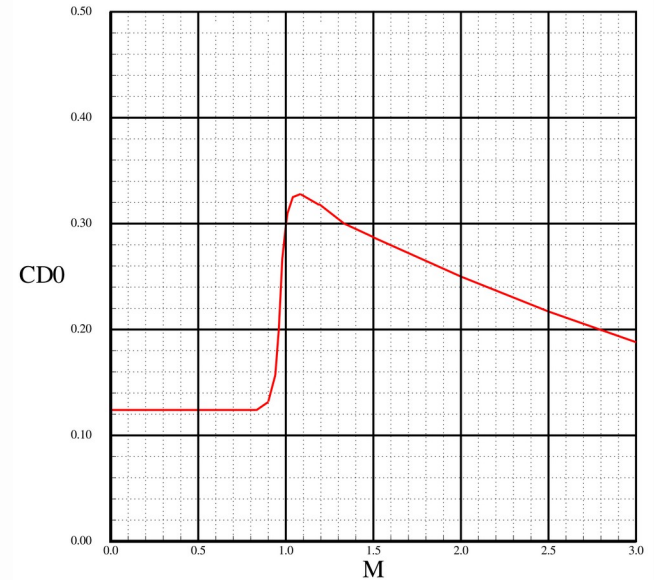
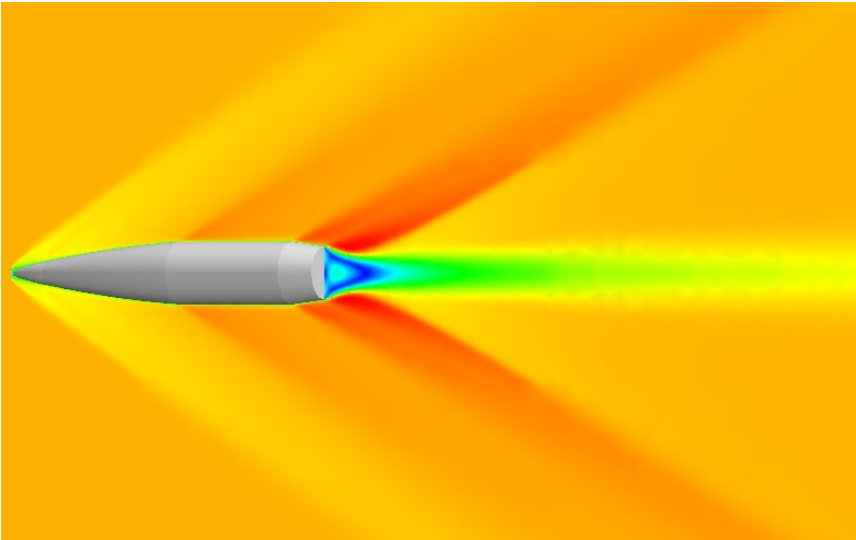
- *Determination of standard muzzle velocities for each charge using CAEeda software.*



Stage-1 : Preparation of Draft FCI & TFT

Aerodynamics calculations

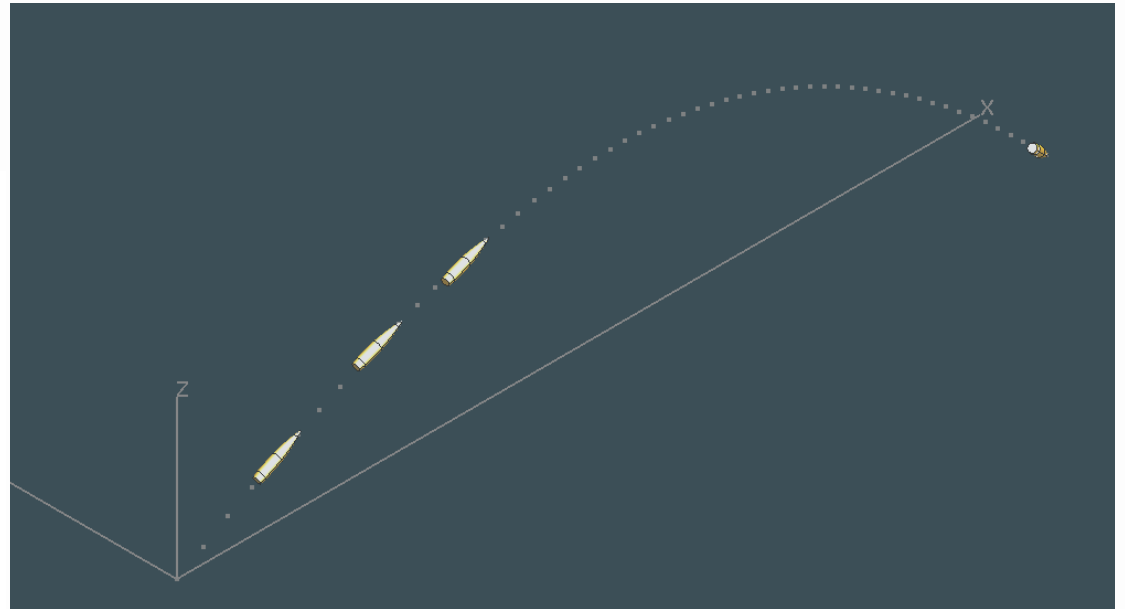
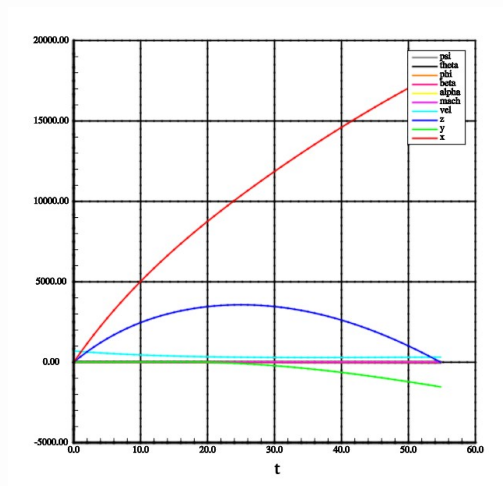
- Computations of aerodynamic coefficients of projectile using CAEeda software



Stage-1 : Preparation of Draft FCI & TFT

Flight mechanics calculations

- *Modified Point Mass Simulations*
- *Calculations of max and min ranges and QE limits and vertex*
- *Test safety calculations*



Stage-1 : Preparation of Draft FCI & TFT

Preparation of draft FCI files and TFT with respect to NATO STANDARDS

FCI files and TFTs are created by recursive and interactive use (automation) of computer code developed by EDA for this purpose specifically.

A sample FCI file

```
<?xml version="1.0" encoding="utf-8"?>
<
  Fingerprint="..." Stamp="...">

<Configuration>
  <Version>1.0</Version>
  <Classification>...</Classification>
</Configuration>

<Projectiles>
  <Projectile Country_Code="..." Model="..." Name="...">
</Projectiles>

<Type>...</Type>
<Family>...</Family>
<Ballistic_Model>MODIFIED POINT MASS</Ballistic_Model>
<Propulsion_Model>UNASSISTED</Propulsion_Model>

<Common_Data>
  <Aerodynamic_Data>
    <All_Phases>
      <CD0>
        <Segment Maximum Mach="0.83">
          <Coeff Term="a0">1.24000000E-01</Coeff>
          <Coeff Term="a1">0.00000000E+00</Coeff>
        </Segment>
        <Segment Maximum Mach="0.9">
          <Coeff Term="a0">2.90000000E-02</Coeff>
```

A sample TFT

1	2	3	4	5	6	7	8		9
RANGE	QUADRANT ELEVATION FOR STANDARD CONDITIONS	FUZE SETTING FOR GRAZE BURST	CORRECTION TO FUZE SETTING TO CHANGE HEIGHT OF BURST DOWN BY 10M	EFFECT ON RANGE FOR INCREASE OF ONE MIL IN ELEVATION	FORK	TIME OF FLIGHT	CORRECTIONS TO BEARING ($\Delta c A_{90}$)		
(X)	(A _{QE})	(FS)	($\Delta cFS/ -10M Y_0$)	($\Delta X/ 1 MIL A_{QE}$)	(F)	(TOF)	DRIFT (CORRECTION TO LEFT)	1 KNOT CROSSWIND	
M	MIL			M	MIL	S	MIL	MIL	
0	0.0				0	0.0	0.0	0.00	
100	5.1	0.3	1.24		0	0.3	0.1	0.00	
200	10.0	0.7	1.10		0	0.7	0.2	0.00	
300	15.0	1.1	0.97		0	1.1	0.3	0.00	
400	20.1	1.3	0.93	20	0	1.3	0.2	0.02	
500	25.2	1.6	0.84	19	0	1.6	0.3	0.02	
600	30.4	1.9	0.77	19	1	1.9	0.3	0.03	
700	35.6	2.3	0.70	19	1	2.3	0.4	0.03	

Firing Tests for Data Acquisition
(FTDA)



Stage-2 : Development of FCI & TFT

Firing test data analysis

- *Data organization*
- *Data reduction by specific statistical methods*

Determination of standard muzzle velocities from firing test data

- *Performed for all charges*

Finding muzzle velocity correction with respect to projectile mass

- *Performed for all charges*



Stage-2 : Development of FCI & TFT

Finding correction factors for aerodynamic coefficients with respect to quadrant elevations

- *Performed for all charges*

Determining probable errors from firing test data using the error budget analysis

- *Calculation PE in range and deflection*
- *Calculation of fork (for up-leg, vertex, down-leg of trajectory)*
- *Performed for all charges*

FCI files are created by recursive and interactive use (automation) of computer code developed by EDA for this purpose specifically.

Stage-2 : Development of FCI & TFT

Preparing TFTs and FCI files for projectile, weapon and fuze with respect to NATO STANDARDS

TFTs are created by recursive and interactive use (automation) of computer code, which accepts FCI files as input, developed by EDA for this purpose specifically.

```
<?xml version="1.0" encoding="utf-8"?>
< Fingerprint="..." Stamp="..." >

<Configuration>
  <Version>1.0</Version>
  <Classification>...</Classification>
</Configuration>

<Projectiles>
  <Projectile Country_Code="..." Model="..." Name="..." />
</Projectiles>

<Type>...</Type>
<Family>...</Family>
<Ballistic_Model>MODIFIED_POINT_MASS</Ballistic_Model>
<Propulsion_Model>UNASSISTED</Propulsion_Model>

<Common_Data>
  <Aerodynamic_Data>
    <All_Phases>
      <CDB>
        <Segment Maximum Mach="0.83">
          <Coeff Term="a0">1.24000000E-01</Coeff>
          <Coeff Term="a1">0.00000000E+00</Coeff>
        </Segment>
        <Segment Maximum Mach="0.9">
          <Coeff Term="a0">2.90000000E-02</Coeff>
```

A sample FCI file

TABLE F (i)
BASIC DATA AND CORRECTIONS TO BEARING

PROJ, HE, CHARGE 5
FUZE, PD, V₀ = 317.2 M/S

1	2	3	4	5	6	7	8	9
RANGE	QUADRANT ELEVATION FOR STANDARD CONDITIONS	FUZE SETTING FOR GRAZE BURST	CORRECTION TO FUZE SETTING TO CHANGE HEIGHT OF BURST DOWN BY 10M	EFFECT ON RANGE FOR INCREASE OF ONE MIL IN ELEVATION	FORK	TIME OF FLIGHT	CORRECTIONS TO BEARING (ΔcA ₀)	
(X)	(A ₀)	(FS)	(Δ _c FS/ -10M Y ₀)	(ΔX/ 1 MIL A ₀)	(F)	(TOF)	DRIFT (CORRECTION TO LEFT)	1 KNOT CROSSWIND
							(A _d)	(1KT W _d)
M	MIL				M	MIL	S	MIL
0	0.0				0	0.0	0.0	0.00
100	5.1	0.3	1.24		0	0.3	0.1	0.00
200	10.0	0.7	1.10		0	0.7	0.2	0.00
300	15.0	1.1	0.97		0	1.1	0.3	0.00
400	20.1	1.3	0.93	20	0	1.3	0.2	0.02
500	25.2	1.6	0.84	19	0	1.6	0.3	0.02
600	30.4	1.9	0.77	19	1	1.9	0.3	0.03
700	35.6	2.3	0.70	19	1	2.3	0.4	0.03

A sample TFT

Firing Tests for Verification and Acceptance (FTVA)



About FCI Files

FCI Files

- › Needed for fire control computer
- › Consisting of four different files
- › Contains ballistic performance information of the Gun & Bullet duo
- › Must be rebuilt if the weapon or ammunition changes
- › Required to create TFT

Weapon File

- Bore diameter, barrel length, rifle twist

Fuse File

- Type and specifications of the fuse

Projectile File

- Aerodynamic coefficients
- Diameter, mass and inertial moments
- "Fitting" inputs
- "Management" inputs
- "Probable Error" inputs
- Charge performance inputs
- Basebleed performance inputs
- Weapon information inputs
- "Fitting", "Management", "Probable Error" and weapon information inputs are calculated separately for each propellant charge

A Sample FCI File



About TFT

These are the tables used to calculate the elevation and bearing of the barrel in order to hit the target, and fuse settings.

They consist of A, B (B1, B2), C, D, E, F (F1, F2, F3), G (G1, G2), H, I, J(J1, J2), K tables.

TFT Samples

TABLE F (i)
BASIC DATA AND CORRECTIONS TO BEARING

PROJ, HE, FUZE, PD, CHARGE 5
V₀ = 317.2 M/S

1	2	3	4	5	6	7	8	9
RANGE (X)	QUADRANT ELEVATION FOR STANDARD CONDITIONS (A _{QE})	FUZE SETTING FOR GRAZE BURST (FS)	CORRECTION TO FUZE SETTING TO CHANGE HEIGHT OF BURST DOWN BY 10M (Δ _c FS/ -10M Y ₀)	EFFECT ON RANGE FOR INCREASE OF ONE MIL IN ELEVATION (Δ _c /1 MIL A _{QE})	FORK (F)	TIME OF FLIGHT (TOF)	CORRECTIONS TO BEARING (Δ _c A _{BB})	
							DRIFT (CORRECTION TO LEFT)	1 KNOT CROSSWIND (1KT W _z)
M	MIL			M	MIL	S	MIL	MIL
0	0.0				0	0.0	0.0	0.00
100	5.1	0.3	1.24		0	0.3	0.1	0.00
200	10.0	0.7	1.10		0	0.7	0.2	0.00
300	15.0	1.1	0.97		0	1.1	0.3	0.00
400	20.1	1.3	0.93	20	0	1.3	0.2	0.02
500	25.2	1.6	0.84	19	0	1.6	0.3	0.02

TABLE F (ii)
CORRECTIONS TO RANGE FOR NON-STANDARD CONDITIONS

PROJ, HE, FUZE, PD, CHARGE 5
V₀ = 317.2 M/S

1	10	11	12	13	14	15	16	17	18	19
RANGE (X)	RANGE CORRECTIONS (Δ _c X)									
	MUZZLE VELOCITY (V ₀) (1 M/S)		RANGE WIND (W _x) (1 KT)		BALLISTIC AIR TEMPERATURE (T _B) (1%)		BALLISTIC AIR DENSITY (D _B) (1%)		PROJ MASS (2 SQ STD) (1 SQ)	
	DEC (-)	INC (+)	HEAD (W)	TAIL (W)	DEC (-)	INC (+)	DEC (-)	INC (+)	DEC (-)	INC (+)
	M	M	M	M	M	M	M	M	M	M
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
100	0.7	-0.7	0.1	0.0	0.1	0.0	0.0	0.0	-2	2
200	1.4	-1.5	0.1	0.0	0.2	0.0	0.0	0.0	-3	3
300	2.1	-2.2	0.1	0.0	0.3	-0.1	-0.1	0.1	-4	4

Tabular Fire Tables (TFT)

- › Prepared by using FCI
- › Prepared for a weapon and bullet combination specifically
- › Based on standard atmospheric conditions (ICAO)
- › Prepared in a specific format in NATO standards
- › Prepared different approaches for direct and indirect firing and each propellant charge separately
- › Calculations for aiming can be done manually by using TTF, but it requires experience, and non-computerized manual calculations take time.
- › TFT-based calculations are not as accurate as FCI-based computational simulations (nonlinear), as they require a lot of interpolation (a linear approach).

Thank you



EDA Engineering Design & Analysis