



# Precision Enhancement build on a Multi Functional Fuze for 155 mm Artillery Munition

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  - Requirements and Solutions
  
- **Part II          Technical Solution**
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  - System Requirements / System Approach
  - Performance / Tactical - Operational Benefits
  - Results of successful System Demonstration on 26 June 2001



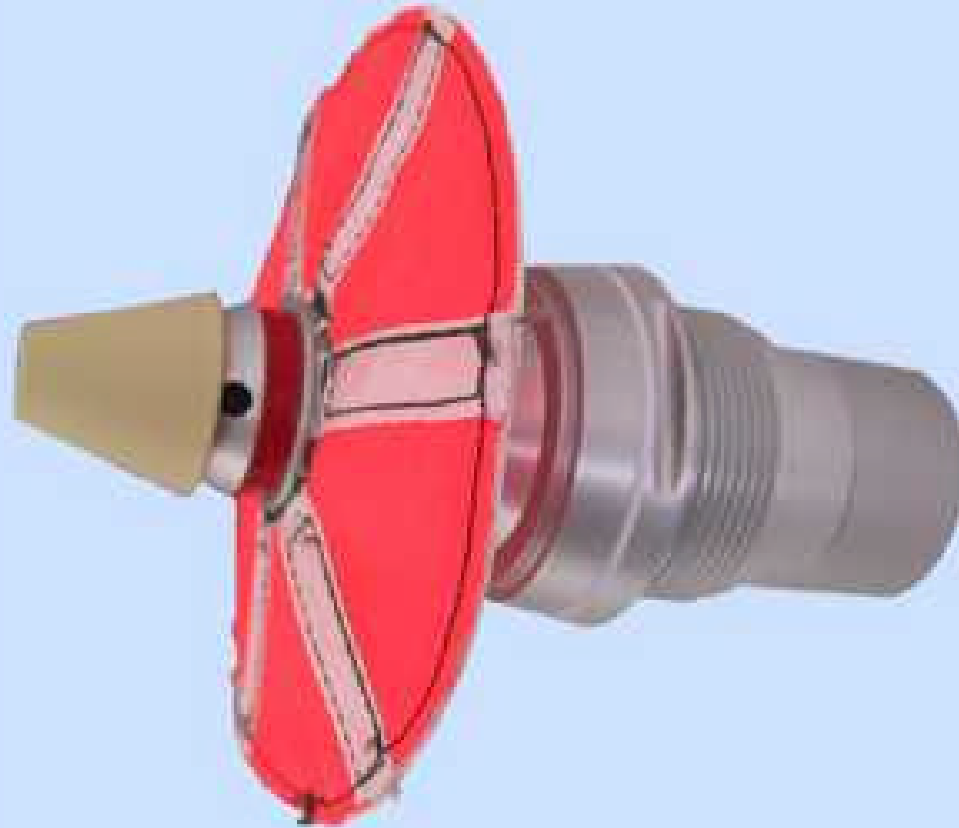
## Operational Gains

- **Increased Accuracy**
  - Better engagement of pinpoint targets
  - Minimized collateral damage
- **Decreased number of rounds to defeat targets**
  - Increased survivability
  - Reduced logistic burden

**Requirements** → **Solutions**

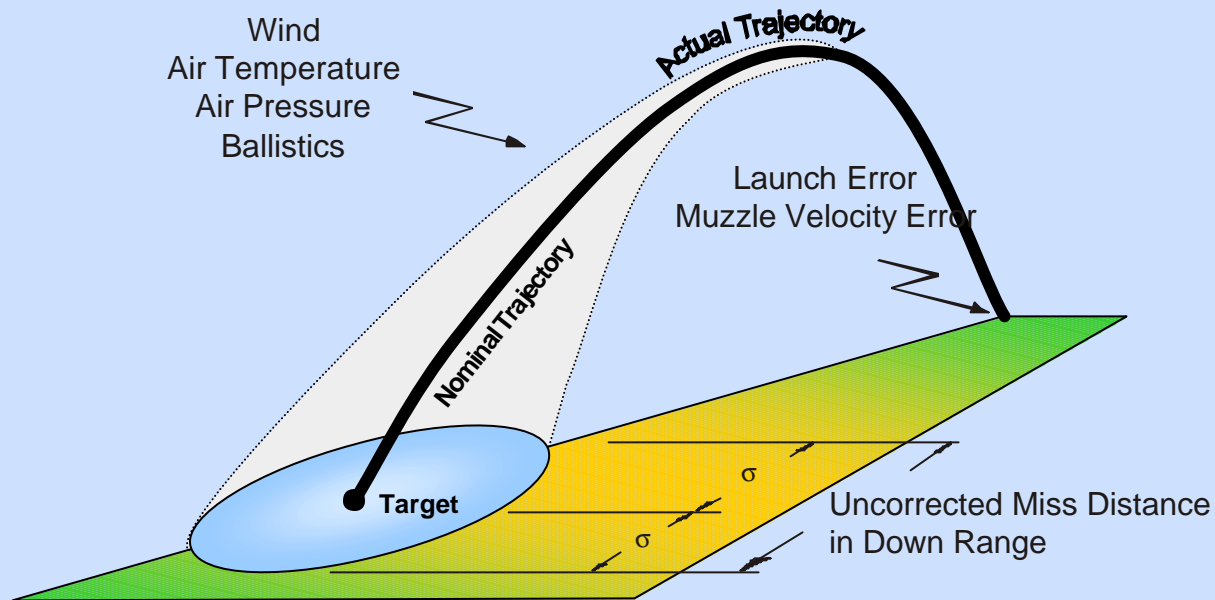
- **Increased Accuracy**
  - ⇒ **Course Correction Device build in Fuze**
- **Low Cost**
  - ⇒ **Air Brake Range Correction ( 1-D )**
- **Fire & Forget**
  - ⇒ **GPS controlled / autonomous Operation**
- **Retrofit for existing shells**
  - ⇒ **Standard 2-inch thread Fuze Shape including multiple functions**

## 1-D Trajectory Correction Fuze (TCF)



## 1-D Trajectory Correction Fuze (TCF)

### Posing the Problem / Technical Approach



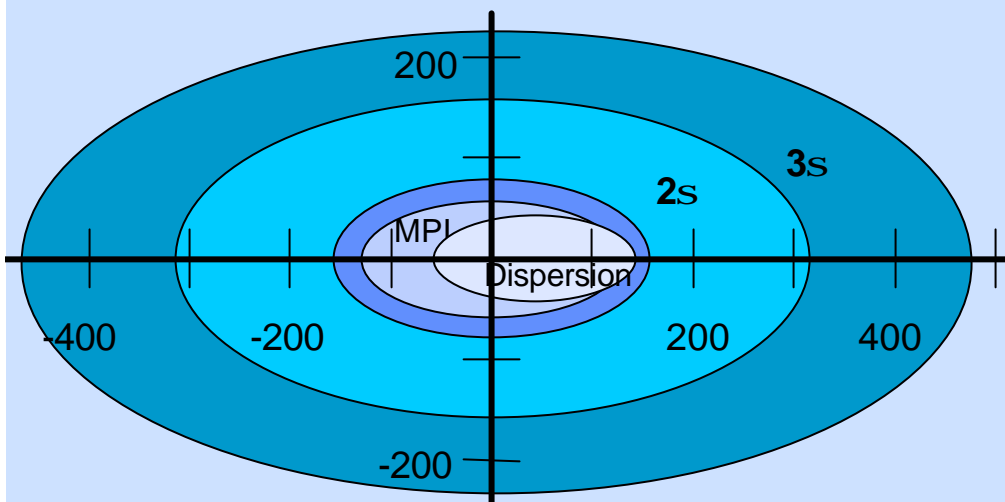
### Active Trajectory Correction (1 D)

- **Sensor Task**  
Detection of Actual Trajectory Variation
- **Control Actuation Task**  
Well-Aimed Trajectory Correction
- **Algorithm Task**  
Calculation and Coordination of optimal Drag Brake Deployment

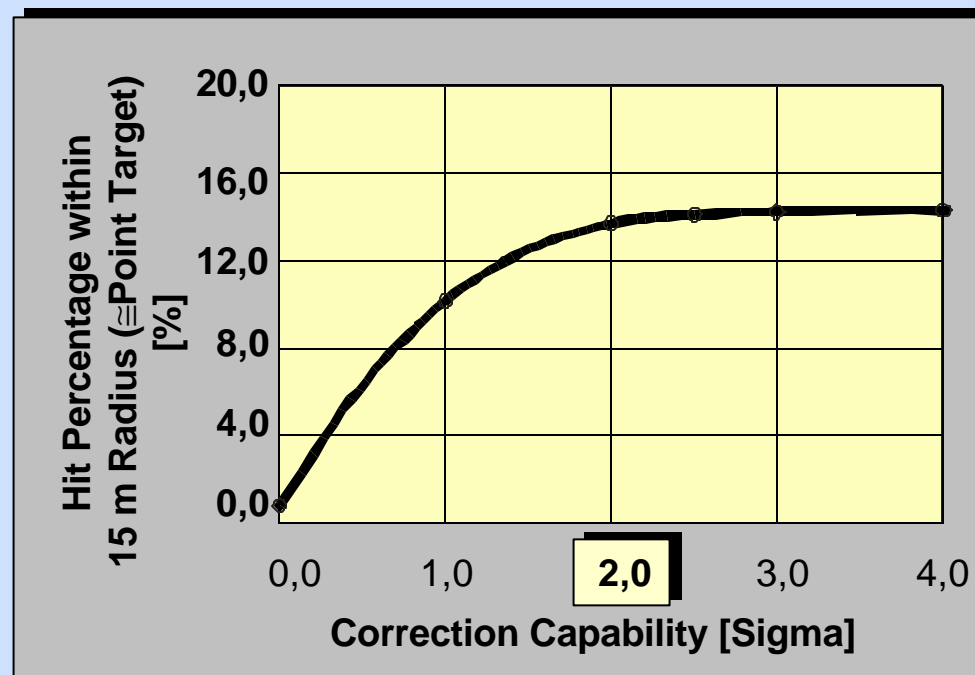


## 1-D Trajectory Correction Fuze (TCF) System Analysis / Required Correction Capability

R = 27 km



Miss Distance

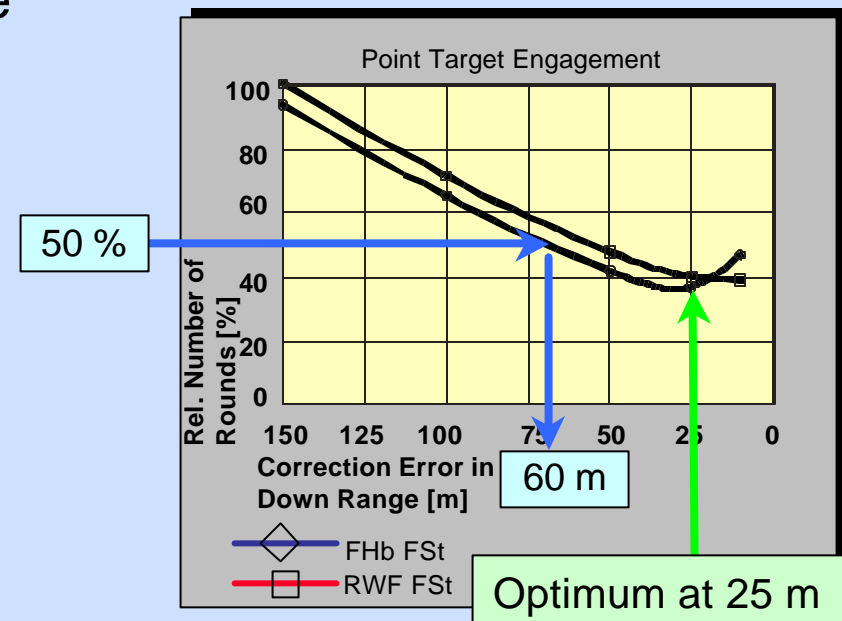
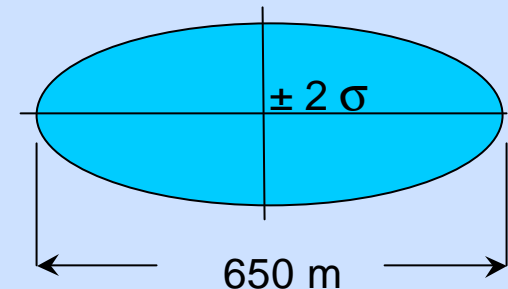


Optimal Correction Capability



## 1-D Trajectory Correction Fuze (TCF) System Requirements

- Maximum Correction Capability of  $\pm 2 s = 650 \text{ m}$  Required
- Induced Error in Cross Range is Neglectible
- Optimum Correction Error in Down Range Resulting for  $1 \sigma = 25 \text{ m}$
- Halving of Number of Rounds Achievable for  $1 s < 60 \text{ m}$





## 1-D Trajectory Correction Fuze (TCF) Sensor / Control Actuation Approach

### ● Sensor Options

- Onboard GPS
  - ◆ Accuracy **independent of Range**
  - ◆ **Fire & Forget** Solution
  
- Ground based Radar and Uplink
  - ◆ Accuracy **dependent of Range**
  - ◆ Munition **Tracking necessary**
  - ◆ **Longer** Stay at Firing Position

### ● Control Actuation

- Simple Mechanics
  - ◆ no moving parts
  - ◆ no servo required
  
- Control
  - ◆ **time discrete**
  - ◆ constant force
  
- Effectiveness
  - ◆ **time variable**
  - ◆ integral effect dependent on time of flight
  - ◆ limited to down range shortening (1 D)

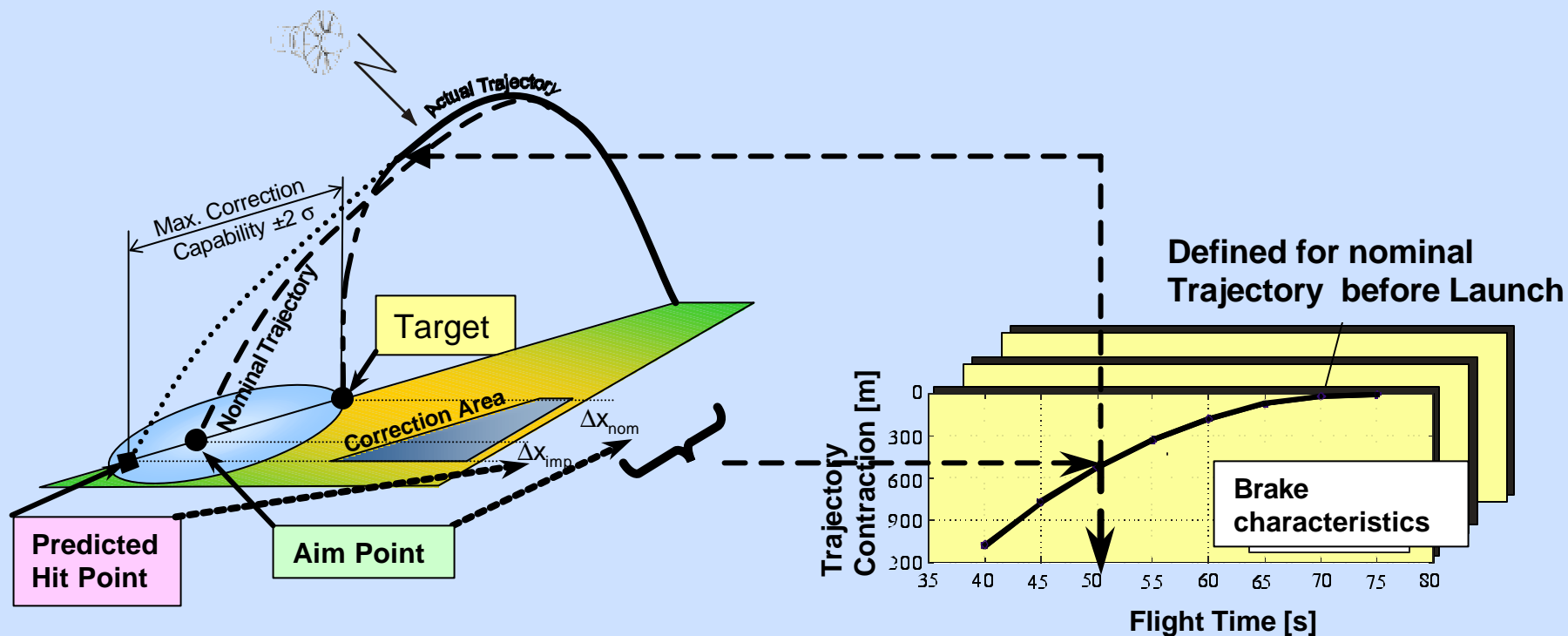
**GPS - the most Cost and  
Mission effective Solution**

**Trajectory Correction by  
Drag Magnification**



# 1-D Trajectory Correction Fuze (TCF)

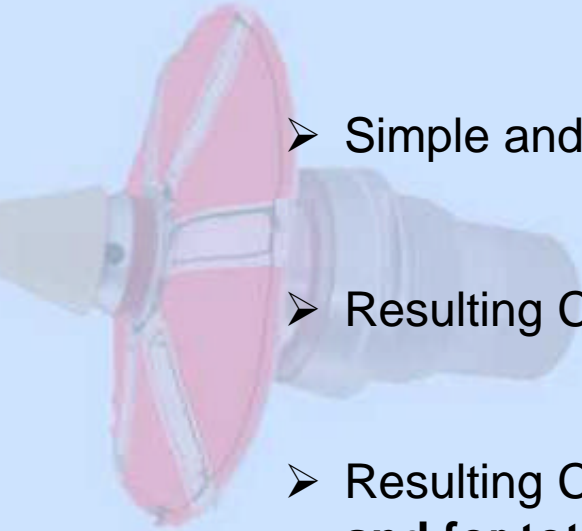
## Correction Algorithm Task



**Hit Point Prediction required for  
Optimal Drag Brake Deployment**



## 1-D Trajectory Correction Fuze (TCF) Performance

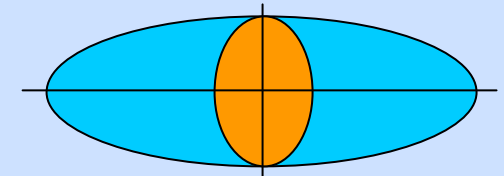
- 
- Simple and robust Algorithm
  - Resulting Correction Error for Ideal **GPS Performance** ~ 25 m
  - Resulting Correction Error for noisy **GPS Performance**  
and for total **GPS Deficiency at 10 km from Target Position** ~ 40 m



**Halving of Number of Rounds achievable even  
under severe Jamming Conditions for GPS**

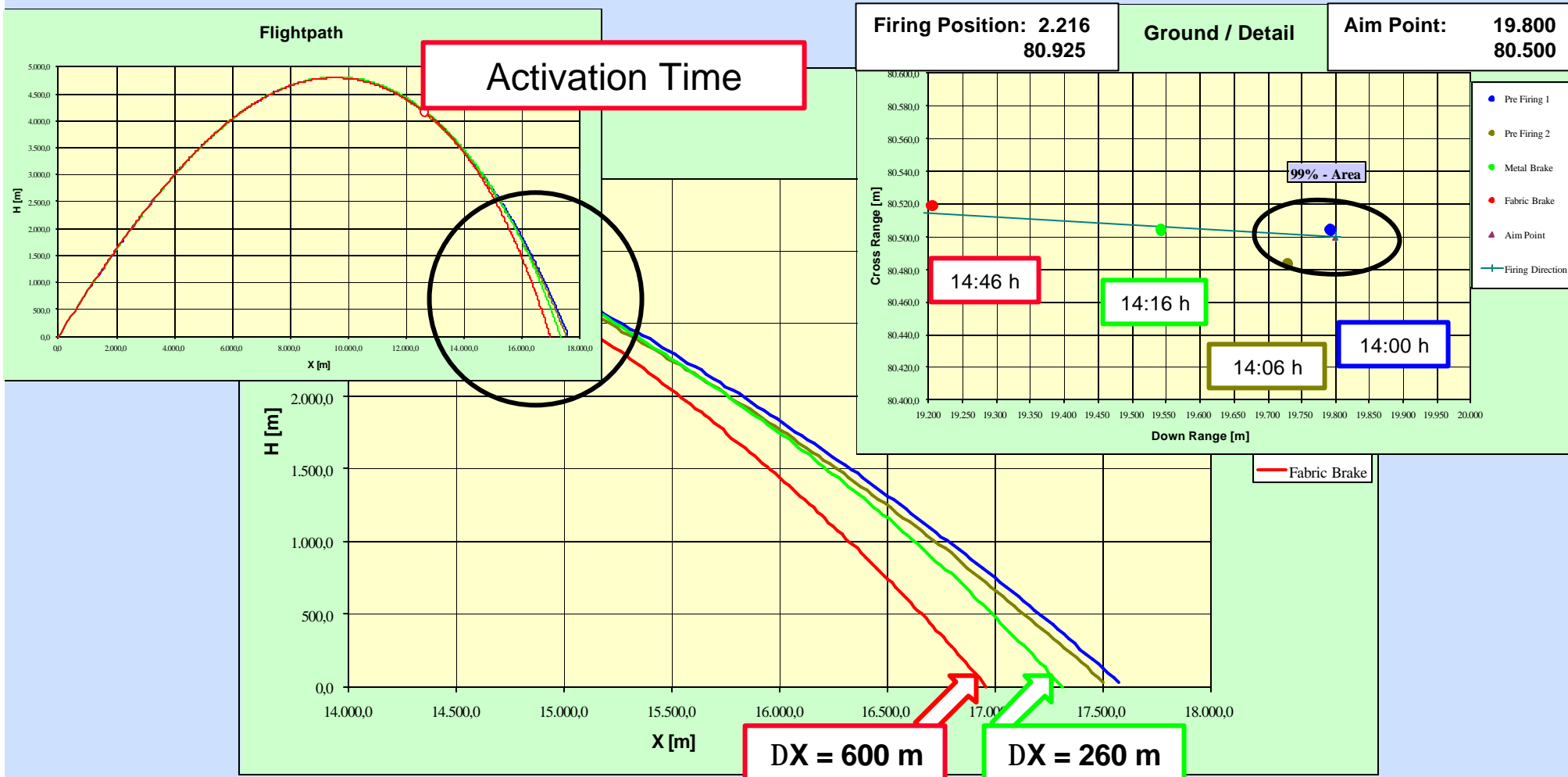
## 1-D Trajectory Correction Fuze (TCF) Tactical - Operational Benefits (HE-Round)

- Reduced Number of Rounds for Target Kill by Factor **2 - 2,5**
- Reduced Cost / Kill by Factor **2**
- Reduced Area of Miss Distance (Collateral Damage) by Factor **4,5**
- Reduced Target Engagement Time
- Reduced Stay at the Firing Position
- Reduced Logistic Burden



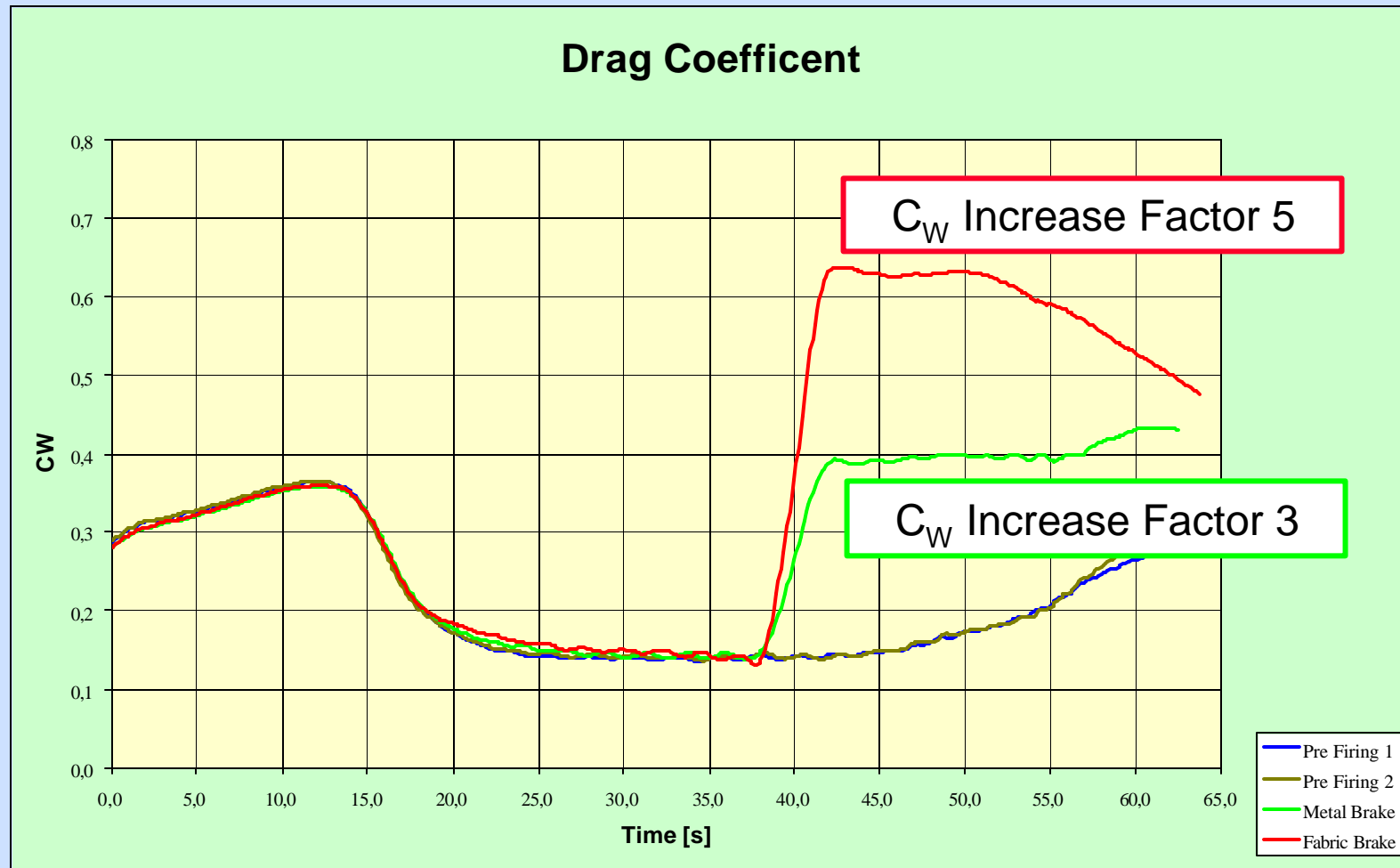
# Successful Demonstration of TCF

26 June 2001, WTD 91, Meppen

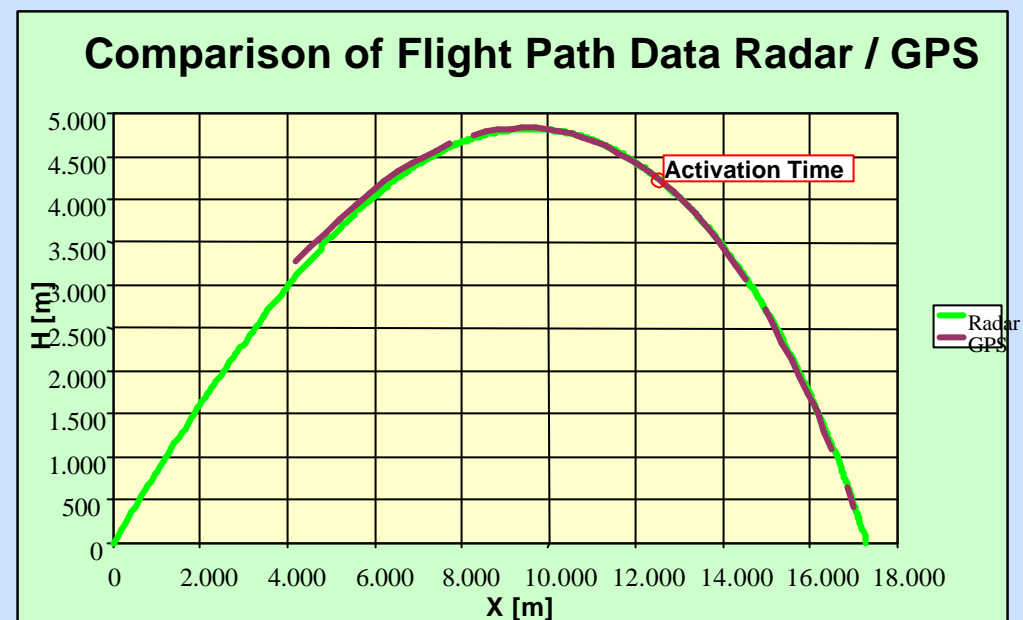
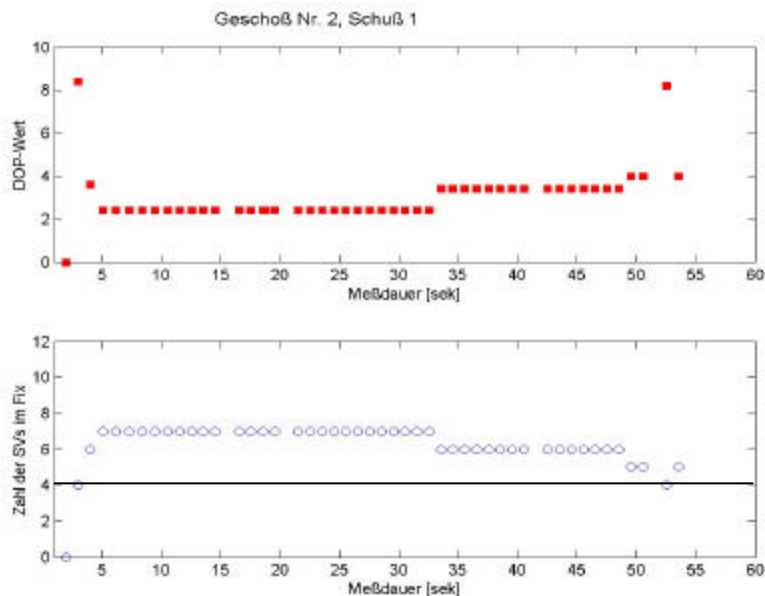


## Successful Demonstration of TCF

26 June 2001, WTD 91, Meppen





## Successful Demonstration of TCF GPS Reception



- 4 Satellites as a Minimum for Calculation required
- 7 Satellites for Calculation mostly available

## Summary

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- **Diehl Munitionssysteme** and **Junghans Feinwerktechnik** have developed the **TCF** concept under contract of the German MOD
  - **Diehl Munitionssysteme** has **successfully demonstrated** the Trajectory Correction Module under contract of the German MOD
  - **Diehl Munitionssysteme** and **Junghans Feinwerktechnik** are ready to enter the full scale development phase of **TCF**
- 







## Precision Enhancement build on a Multi Functional Fuze for 155 mm Artillery Munition

**Thank you for your attention**

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WF 15

**DIEHL**  
Munitionssysteme



**QUESTIONS ?**





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