



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

Bundesamt für Wehrtechnik und Beschaffung  
BOR Dr. rer. nat. Olaf Reusch

D-56073 Koblenz

Diehl Munitionssysteme GmbH & Co. KG  
Dipl.-Ing. Karl B. Kautzsch

D-90552 Roethenbach / Pegnitz

Germany

**47<sup>th</sup> NDIA**

**Annual Fuze Conference**

**April 8 - 10, 2003**

**New Orleans, LA, U.S.A.**



## Content

- **Part I          Required Capabilities**
  - Operational Gains
  - Requirements and Solutions
  
- **Part II          Technical Solution**
  - Posing the Problem / System Analysis
  - 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



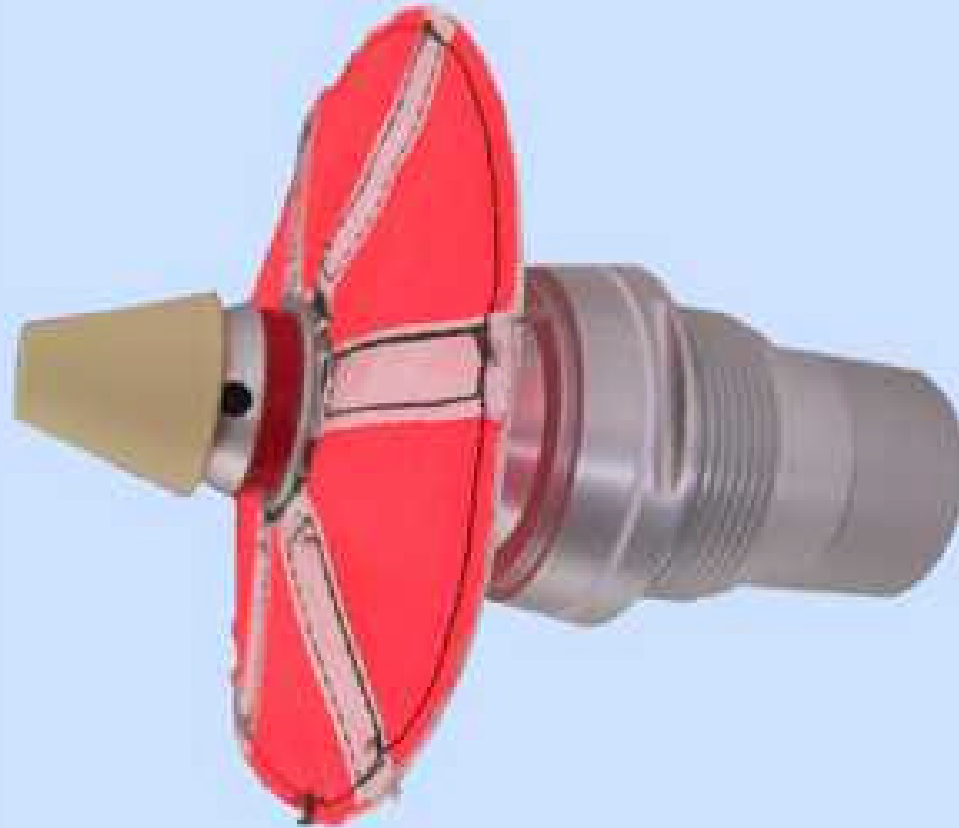
**Requirements**



**Solutions**

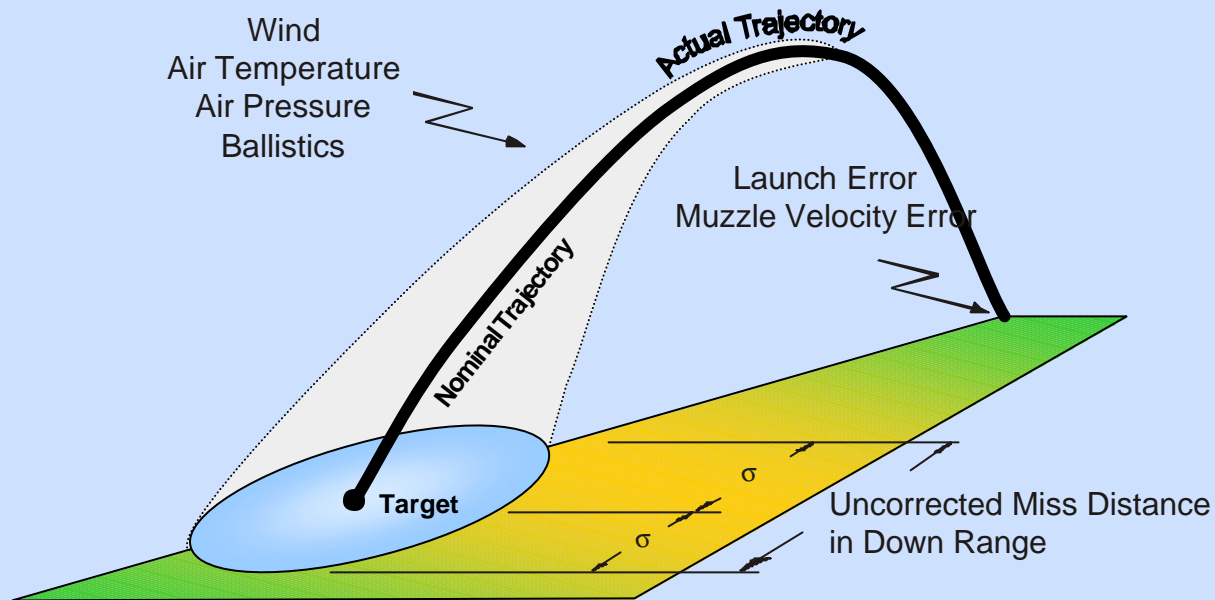
- **Increased Accuracy**
  - ⇒ **Course Correction Device build in Fuze**
- **Low Cost**
  - ⇒ **Air Brake Range Correction ( 1-D )**
- **Fire & Forget**
  - ⇒ **GPS controlled / autonomous Operation**
- **Retrofit for existing shells**
  - ⇒ **Standard 2-inch thread Fuze Shape including multiple functions**

## 1-D Trajectory Correction Fuze (TCF)



## 1-D Trajectory Correction Fuze (TCF)

### Posing the Problem / Technical Approach



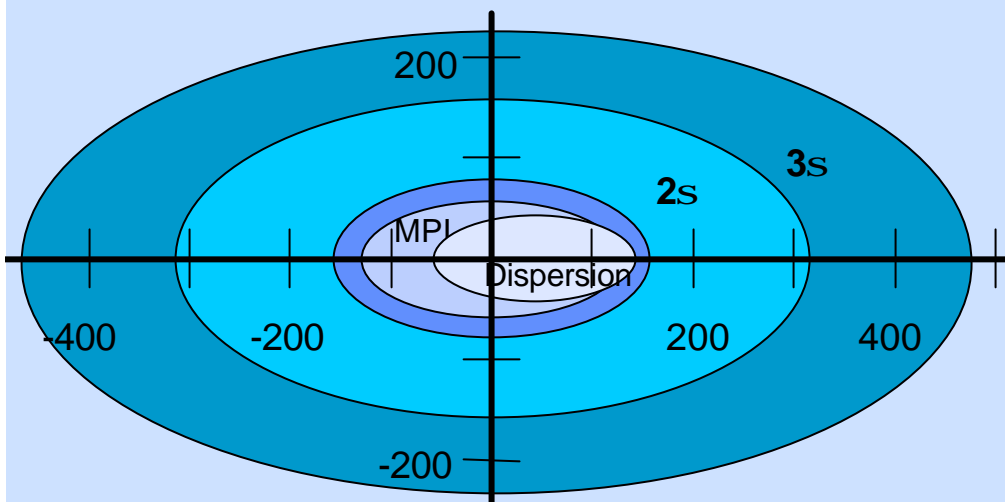
### Active Trajectory Correction (1 D)

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

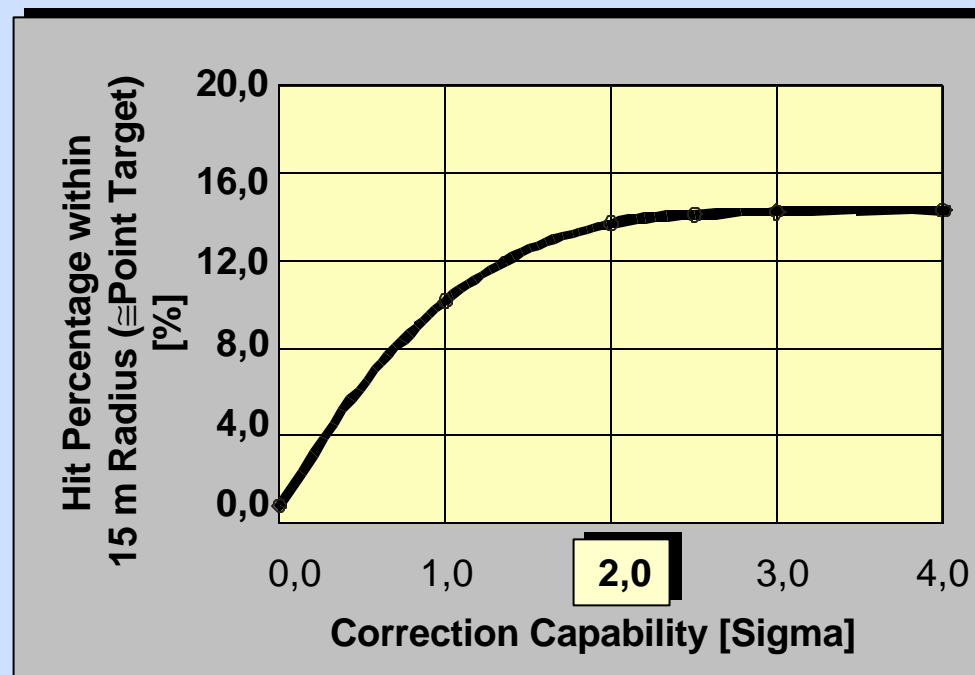


## 1-D Trajectory Correction Fuze (TCF) System Analysis / Required Correction Capability

R = 27 km



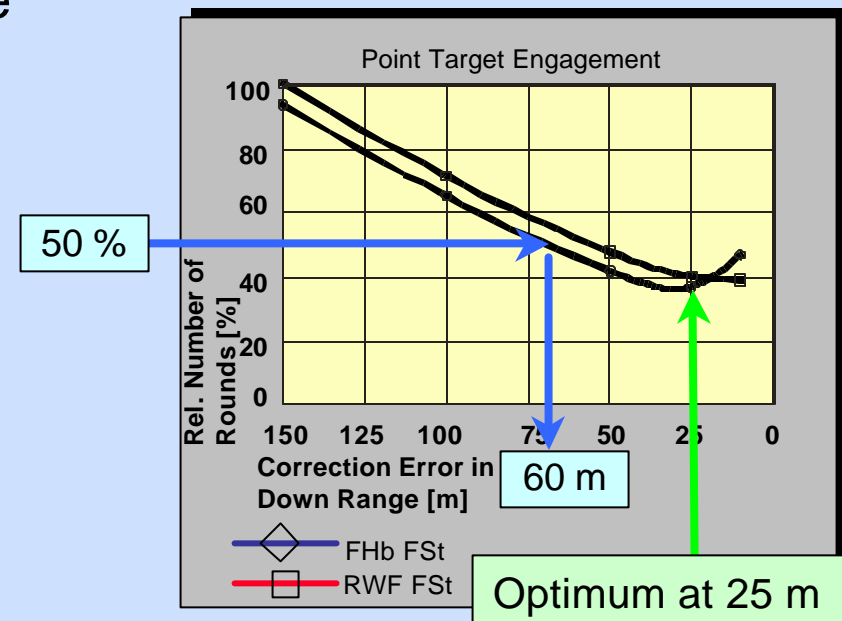
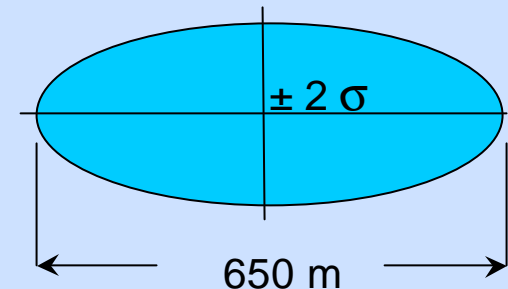
Miss Distance



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)

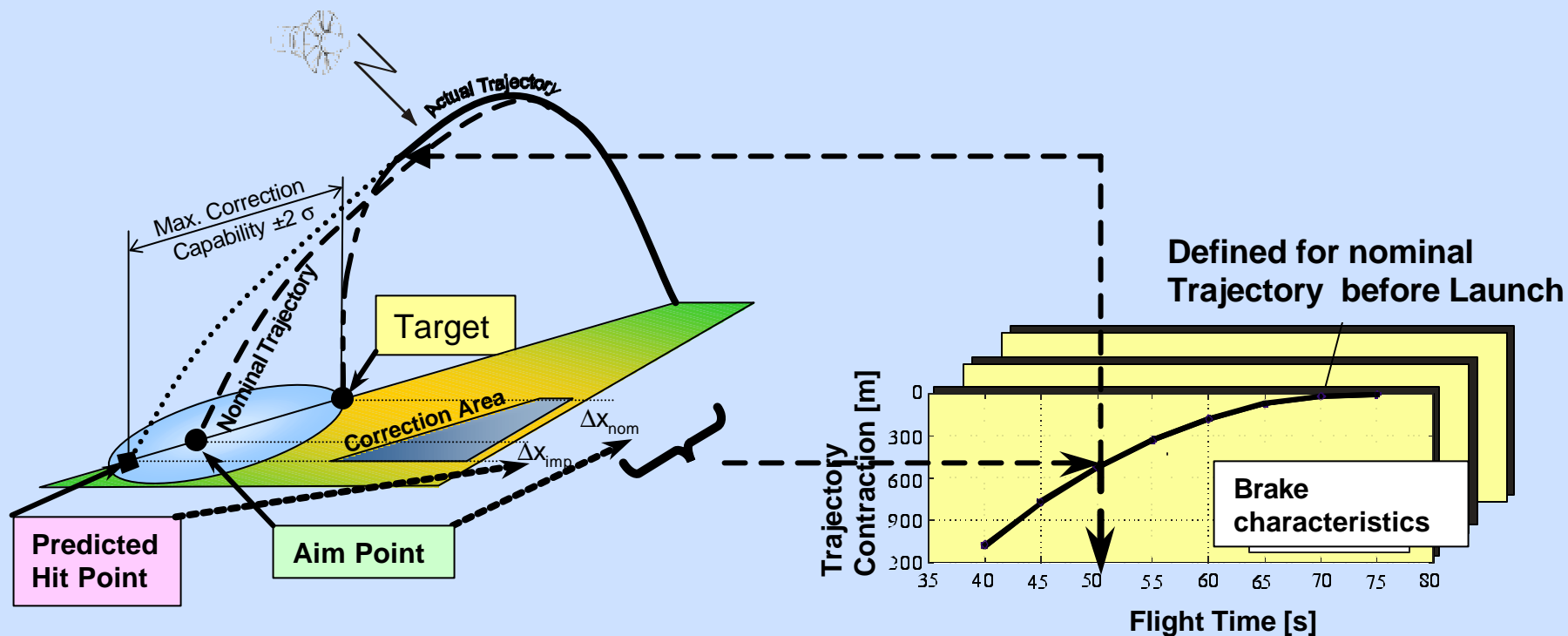
**GPS - the most Cost and  
Mission effective Solution**

**Trajectory Correction by  
Drag Magnification**



# 1-D Trajectory Correction Fuze (TCF)

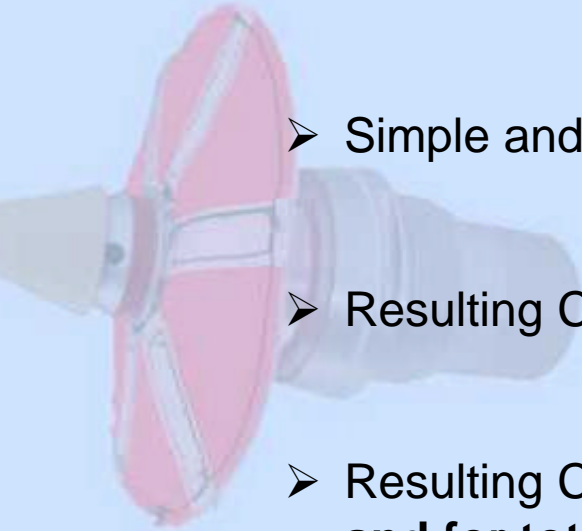
## Correction Algorithm Task



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



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

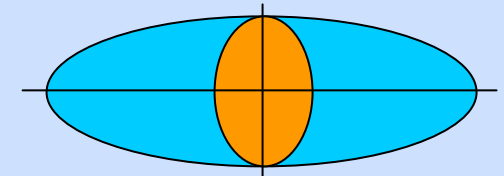
- 
- Simple and robust Algorithm
  - Resulting Correction Error for Ideal **GPS Performance** ~ 25 m
  - Resulting Correction Error for noisy **GPS Performance**  
and for total **GPS Deficiency at 10 km from Target Position** ~ 40 m



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

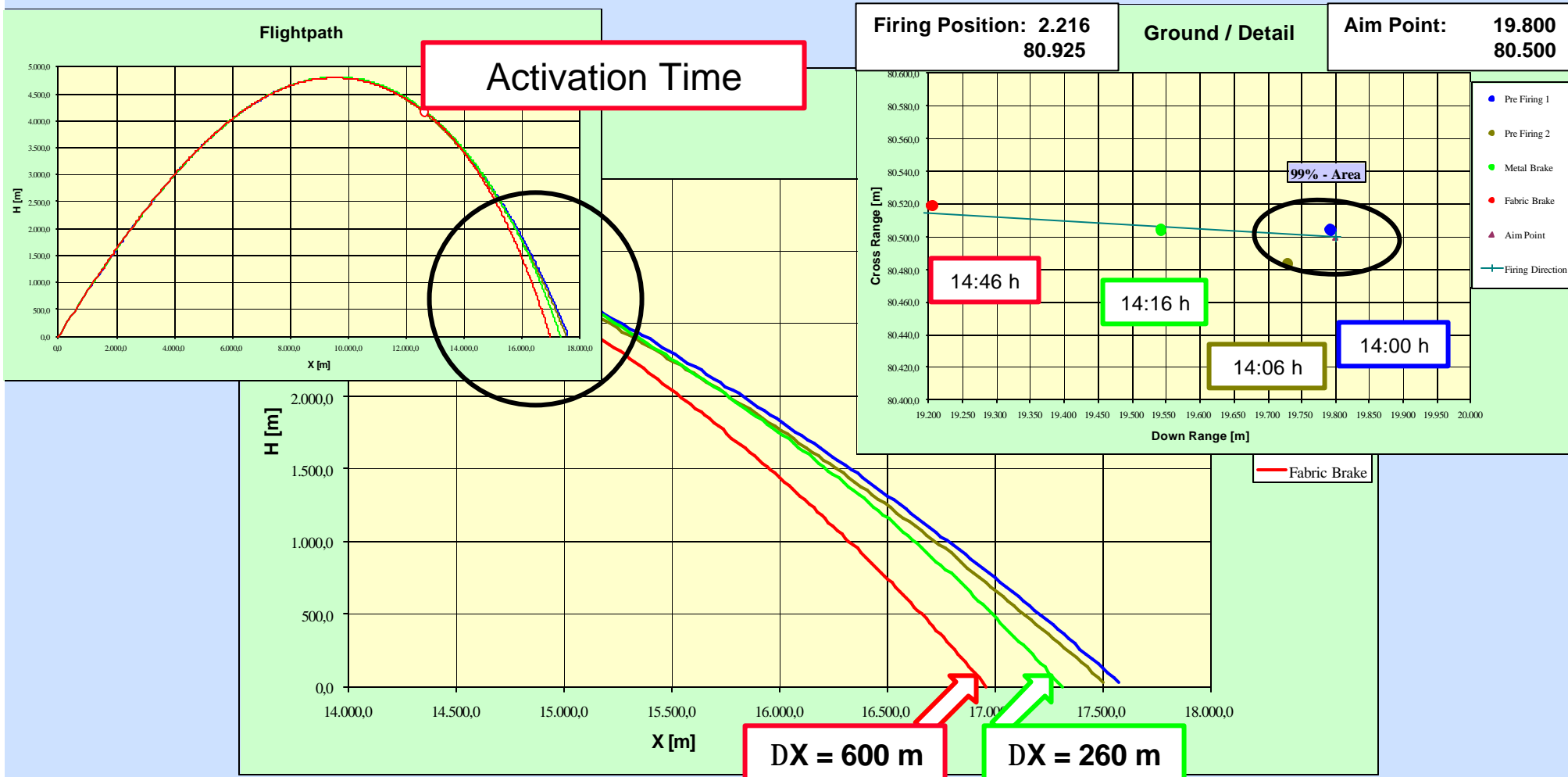
## 1-D Trajectory Correction Fuze (TCF) Tactical - Operational Benefits (HE-Round)

- 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



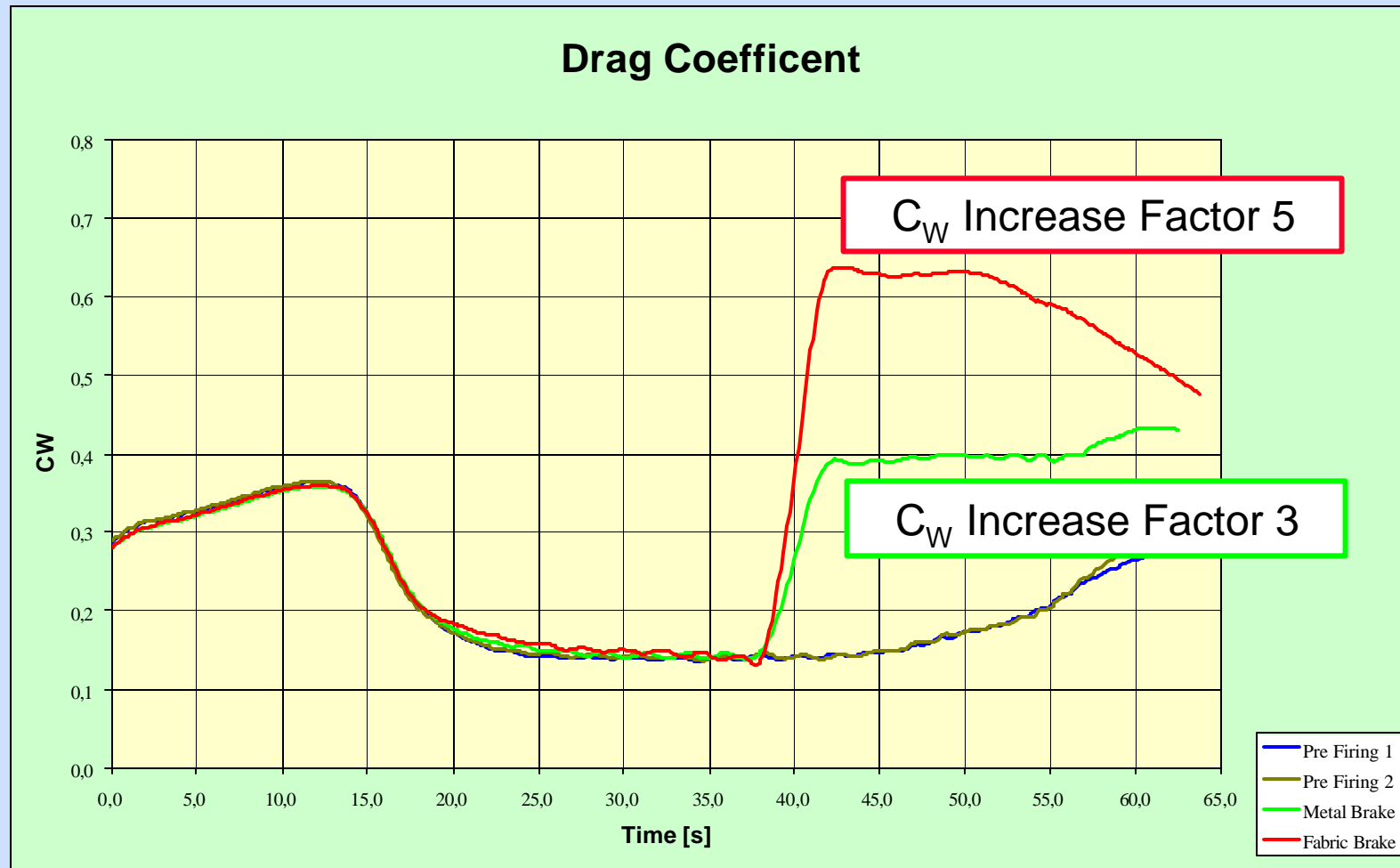
# Successful Demonstration of TCF

26 June 2001, WTD 91, Meppen

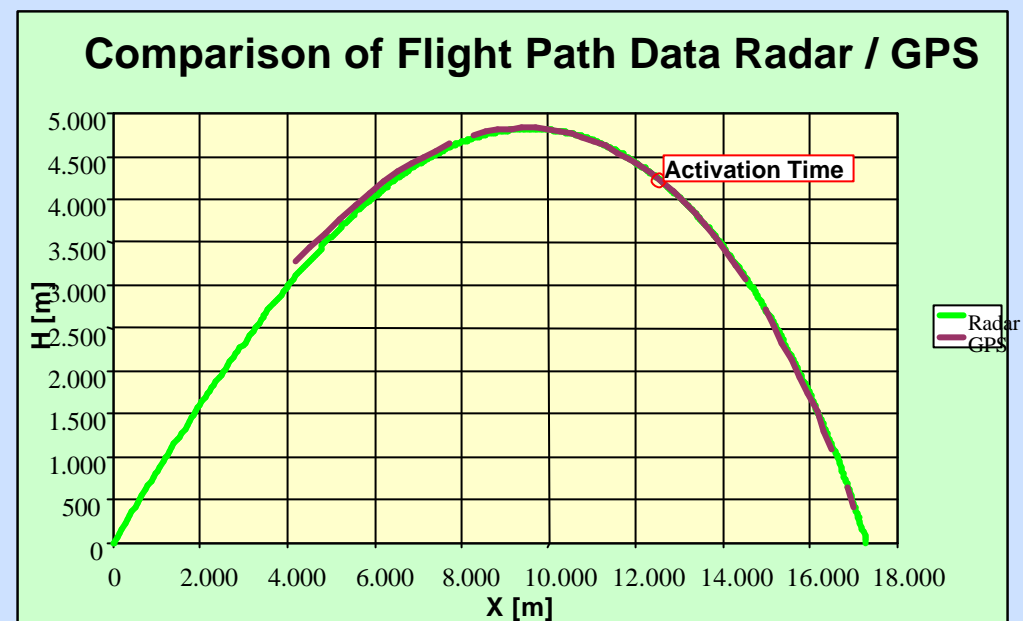
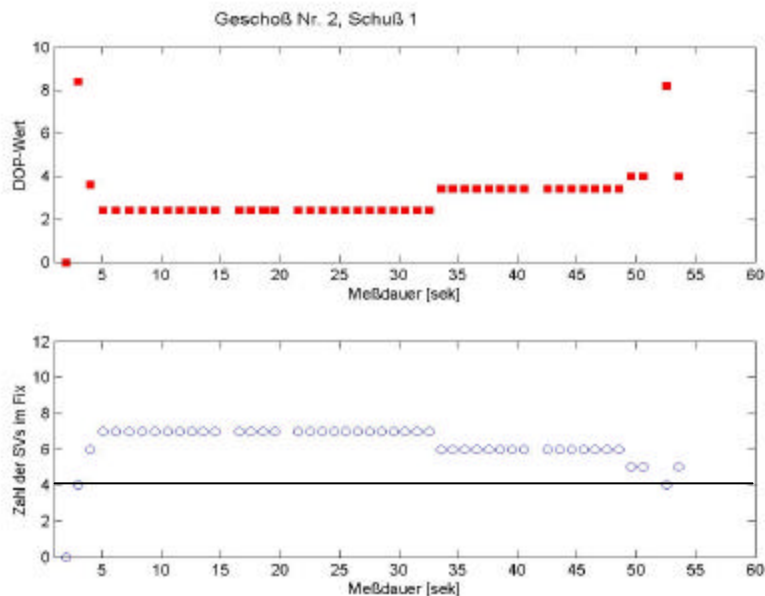


## Successful Demonstration of TCF

26 June 2001, WTD 91, Meppen



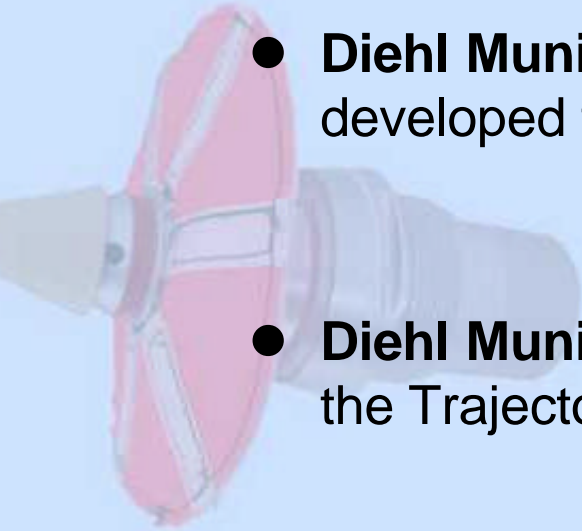

## Successful Demonstration of TCF GPS Reception



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



## Summary

- 
- **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**

**Bundesamt für Wehrtechnik und Beschaffung**  
D-56073 Koblenz

**Germany**

**Diehl Munitionssysteme GmbH & Co. KG**  
D-90552 Roethenbach / Pegnitz





WF 15

**DIEHL**  
Munitionssysteme



**QUESTIONS ?**





## Points of Contact

### **Bundesamt für Wehrtechnik und Beschaffung**

Ferdinand-Sauerbruch-Strasse 1

D-56073 Koblenz

Germany

BOR Dr. rer. nat. **Olaf Reusch**

Tel.: \*49 - 261 - 400 - 7436

Fax: \*49 - 261 - 400 - 6593

e-mail: [OlafReusch@bwb.org](mailto:OlafReusch@bwb.org)

### **Diehl Munitionssysteme GmbH & Co. KG**

Fischbachstrasse 16

D-90552 Roethenbach / Pegnitz

Germany

Technique: Dipl.-Ing. **Karl B. Kautzsch**

Tel.: \*49 - 911 - 957 - 2936

Fax: \*49 - 911 - 957 - 2710

e-mail: [karl.kautzsch@diehl-mun.de](mailto:karl.kautzsch@diehl-mun.de)

Marketing: LTC (ret.) **Georg Stammel**

Tel.: \*49 - 911 - 957 - 2995

Fax: \*49 - 911 - 957 - 2653

e-mail: [georg.stammel@diehl-mun.de](mailto:georg.stammel@diehl-mun.de)

