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

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47th NDIA
Annual Fuze Conference
April 8 - 10, 2003
New Orleans, LA, U.S.A.
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  - Operational Gains  
  - Requirements and Solutions

- **Part II**  
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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
- 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
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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
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1-D Trajectory Correction Fuze (TCF) System Analysis / Required Correction Capability

R = 27 km

Optimal Correction Capability

Hit Percentage within 15 m Radius (≅ Point Target) [%]

Correction Capability [Sigma]

Miss Distance

Optimal Correction Capability
1-D Trajectory Correction Fuze (TCF)

- Maximum Correction Capability of $\pm 2 \sigma = 650 \text{ m}$ 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 $1 \sigma < 60 \text{ m}$
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
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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
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Successful Demonstration of TCF
26 June 2001, WTD 91, Meppen

Flightpath

Activation Time

Firing Position: 2.216

80.925

Ground / Detail

Aim Point: 19.800

80.500

Down Range [m]

Cross Range [m]

Pre-Firing 1

Pre-Firing 2

Metal Brake

Fabric Brake

Activation Time

\[ \Delta X = 600 \text{ m} \]

\[ \Delta X = 260 \text{ m} \]
Successful Demonstration of TCF
26 June 2001, WTD 91, Meppen

Drag Coefficient

Time [s]

C_W Increase Factor 5

C_W Increase Factor 3

Pre Firing 1
Pre Firing 2
Metal Brake
Fabric Brake
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Successful Demonstration of TCF GPS Reception

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

Comparison of Flight Path Data Radar / GPS

- Activation Time

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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**.
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Thank you for your attention

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QUESTIONS ?
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