

# *Ultrasonic Temperature and Heat Flux Sensor Technology*



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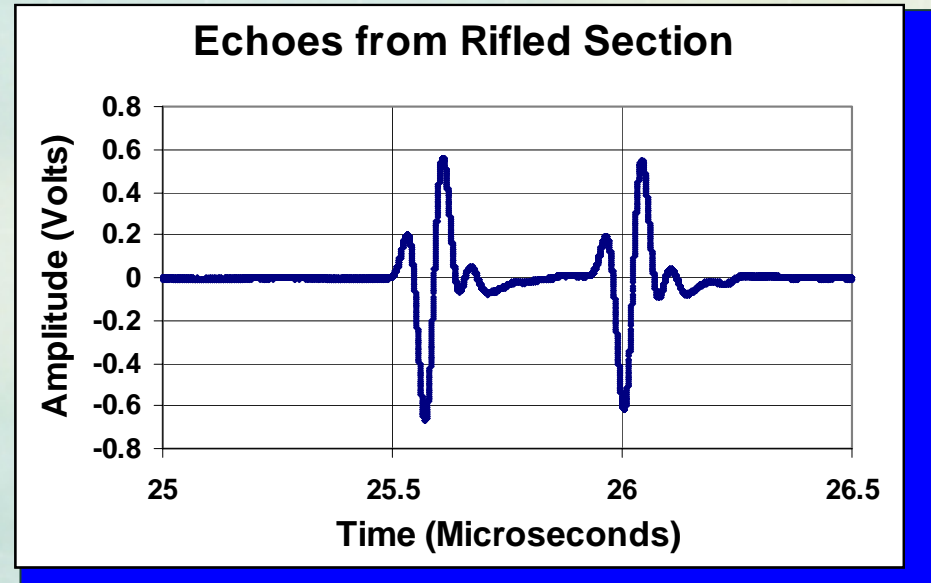
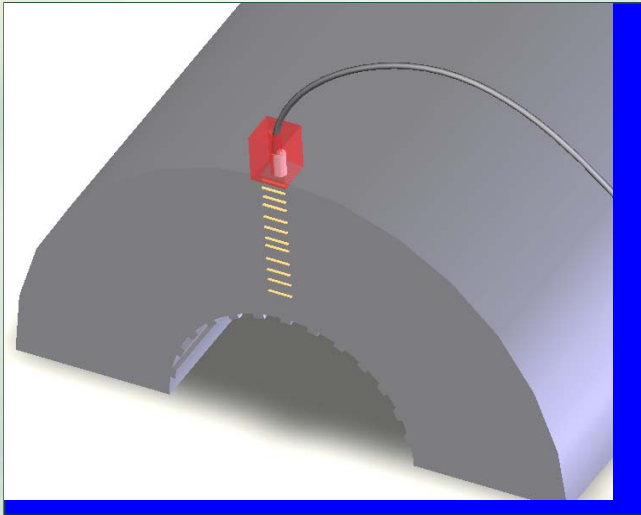
# Problem Statement

- Auto ignition or “cook-off” is one of the most serious safety concerns when firing large caliber guns.
- Researchers inability to perform measurements at locations where they are needed



# Measurement Concept Temperature

- Precise Timing Measurements to Measure Temperature & Erosion



## Determining Inner Chamber Surface Temperature

$$\frac{\text{Change of Echo Separation}}{(\text{Velocity Temperature Coefficient}) \times (\text{Echo Separation})}$$

# Mark 45 MOD 4 Live Fire Trials

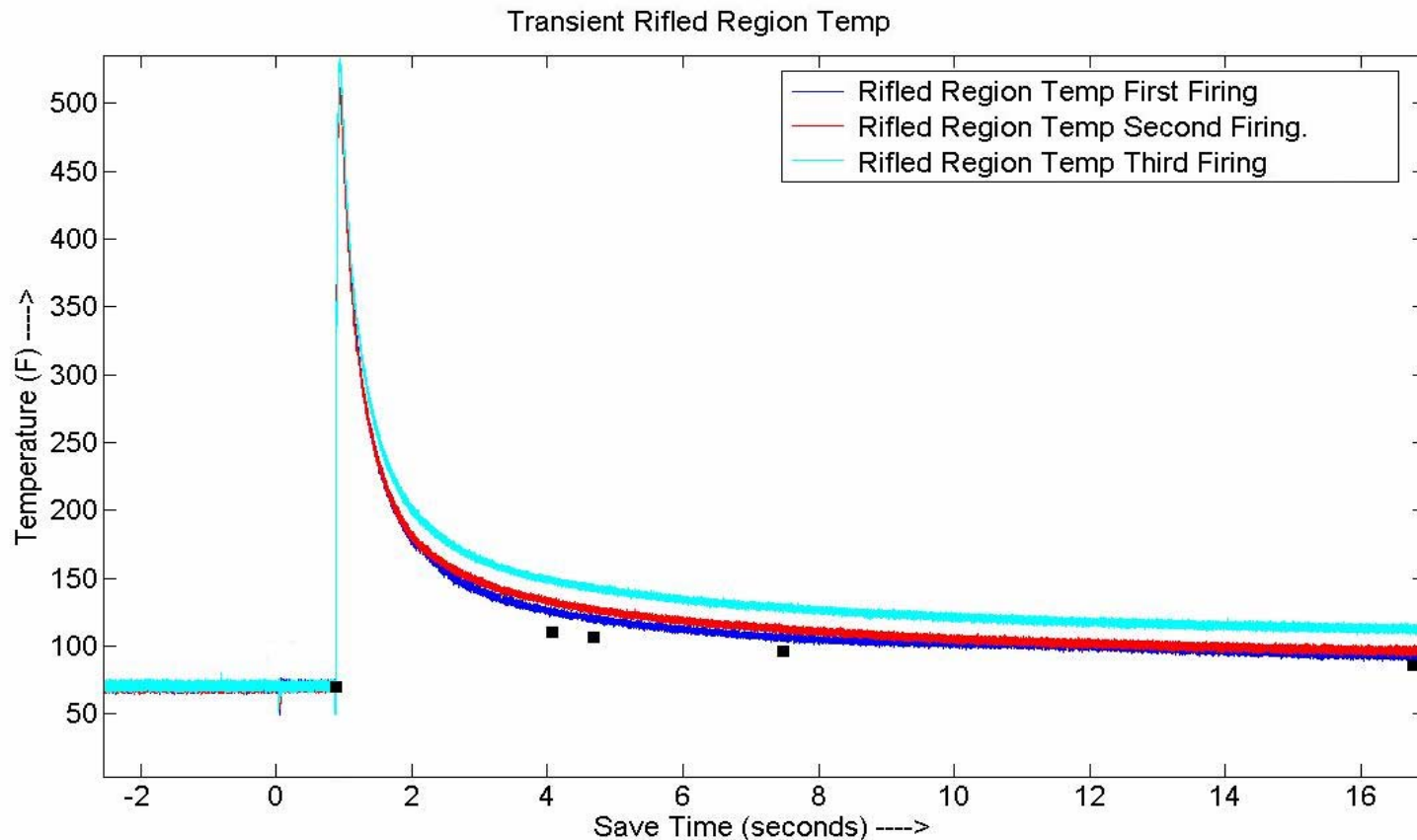
## Multiple Successful Live Fire Trials

NETS (NON-Intrusive Erosion and Temperature Sensor) prototype installed on the MK45 MOD 4 Gun at NSWCCD for several live fire experiments in 2005-2006



- Accurate Internal Temperature Measurement
- Transient Temperature Measurement
- Off-line Heat Flux Calculations

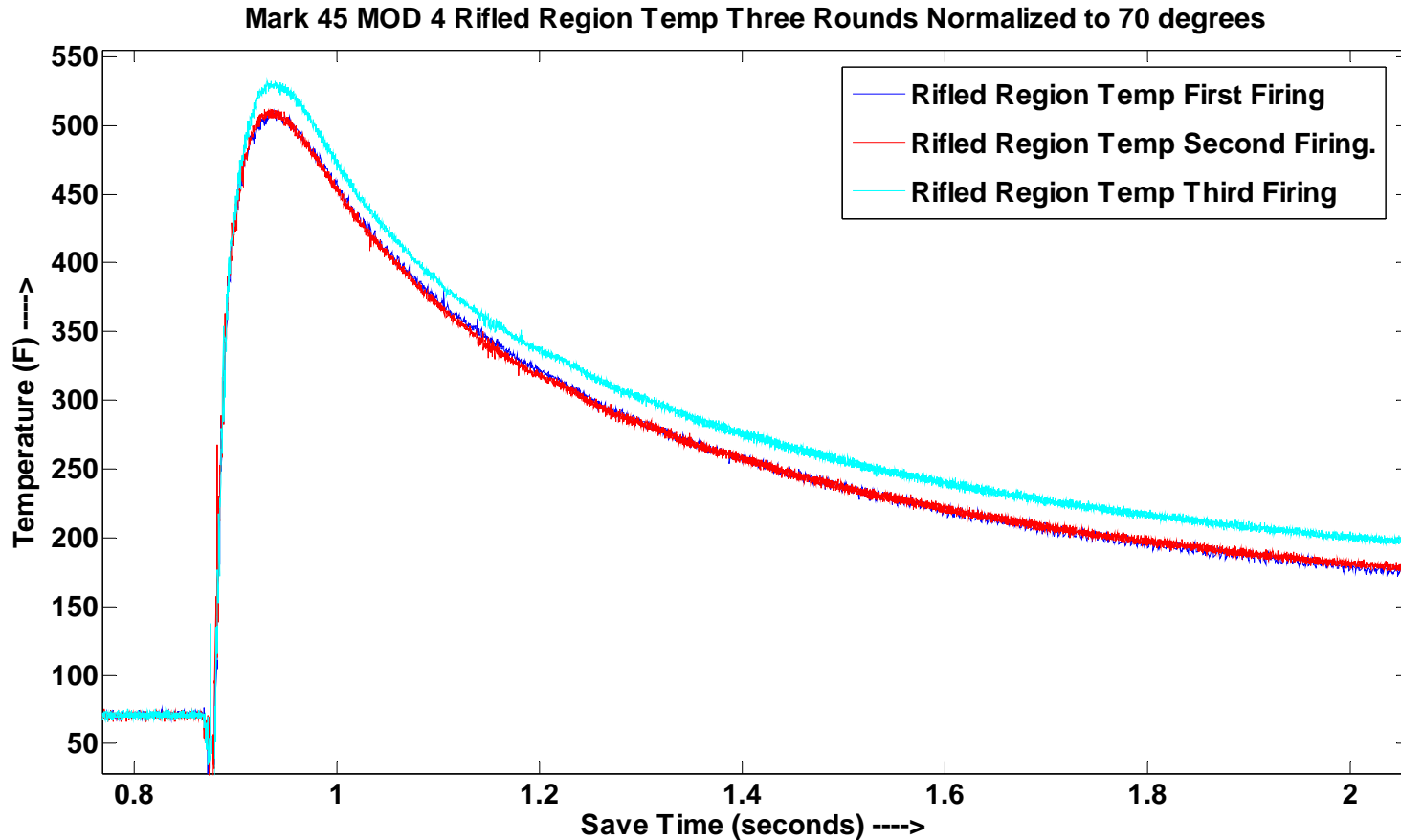
# Precise Internal Temperature Measurement



Ultrasonic Temperature for Three Firings of Mark 45 Mod 4 Normalized to 70 degrees Fahrenheit.

(Black Squares are Thermocouple based modeled data provided by NSWCDD)

# Transient Temperature Measurement

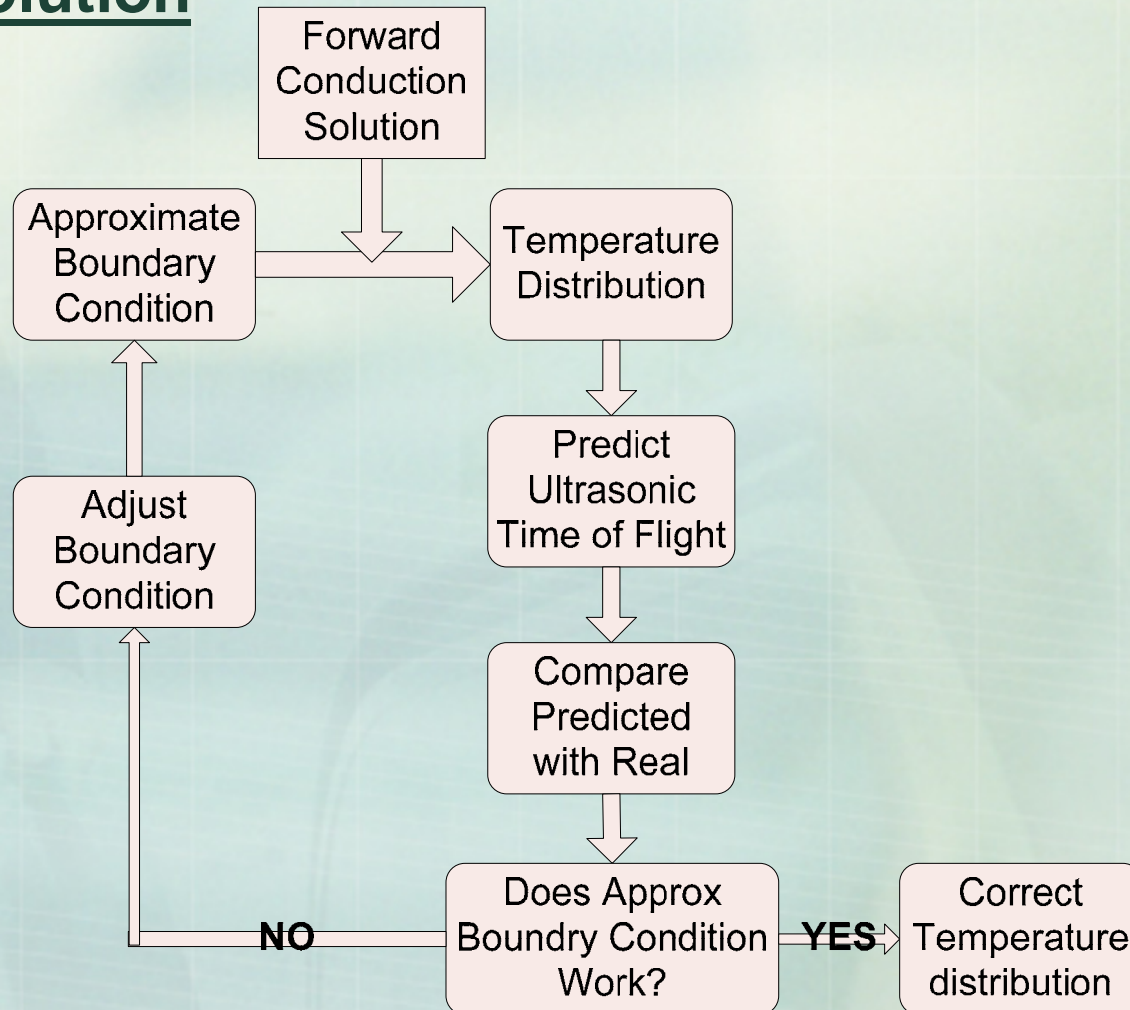


Technology offers the potential for temperature measurement on a microsecond timeframe.

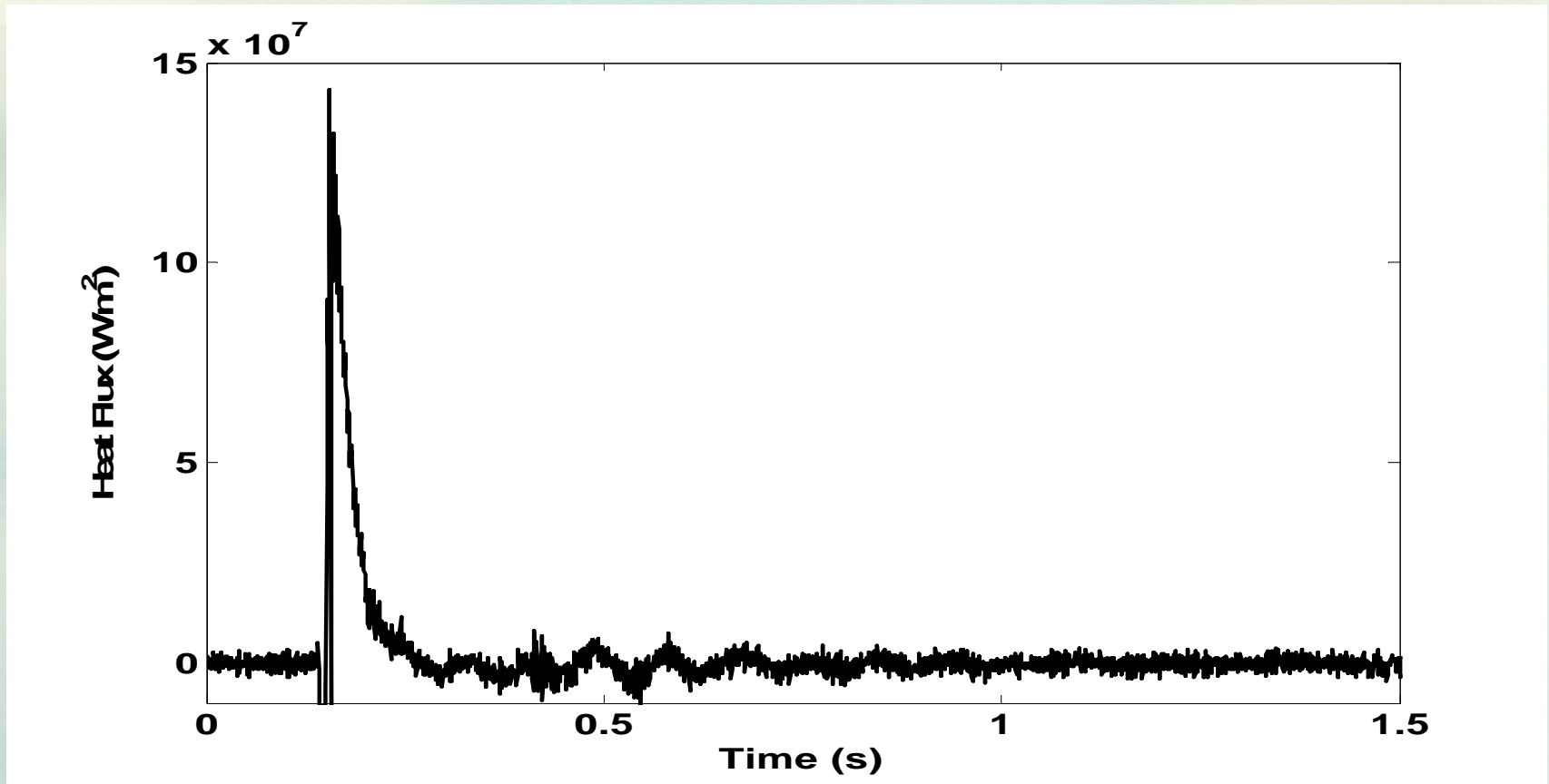
(Ultrasonic Temperature data collect every 200 usec.)

# Measurement Concept for Heat Flux:

## Inverse Solution



# Off-line Heat Flux Calculations



Ultrasonic based Heat Flux determination at the Gun Bore Interface over A period of 1.5 seconds



# Measurement Possibilities for the *Ultrasonic Temperature and Heat Flux Sensor*

## Features, Advantages, and Benefit of the Ultrasonic Technology

Features	Advantages	Benefits
Gun Temperature	Non-Intrusive Direct Measurement	Increased Gun Safety
Gun Erosion	At Sea Measurement Continuously Monitor	Tactical and Safety
Transient Temperature	Non-Intrusive High Speed Measurements	Barrel Coatings/ Propellants Combustion Instability
Heat Flux	Non-Intrusive High Speed Response	Barrel Coatings/ Propellants Gun Research

# Opportunities for the *Ultrasonic Temperature and Heat Flux Sensor*

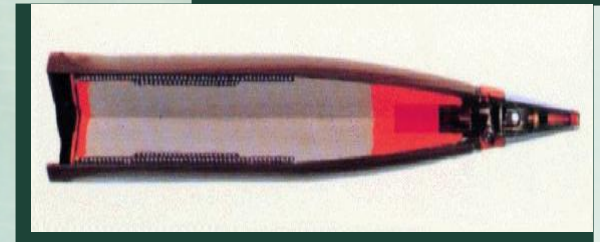
## Gun Safety

- 5"/62 MK 45 MOD 4 gun
- BOFORS MK 110 57mm gun US Coast Guard & Navy
- Lightweight Howitzer (JLWH) 155mm Program



## Research

- 155mm Advanced Gun System for DD(X)
- US Army Benet Laboratory Gun
- Barrel Coating & Munitions Research
- Combustion Chamber Instabilities
- Insulating And Metallic Aeroshells



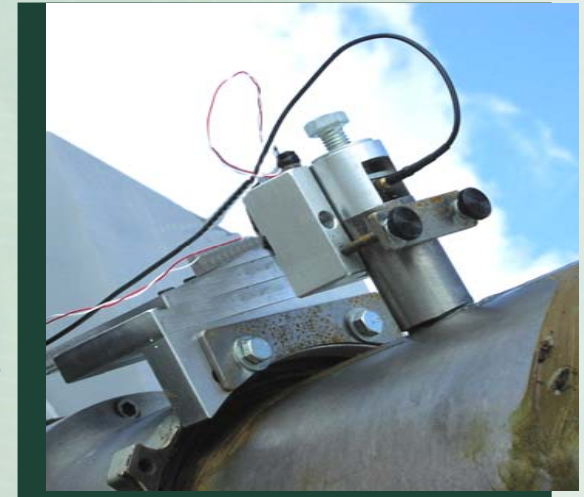
# State of Development for the *Ultrasonic Temperature and Heat Flux Sensor*

## ACCOMPLISHMENTS:

- DEVELOPED concept of a sound sensor for temperature and heat flux algorithms
- IMPLEMENTED in both lab and live fire environments
- DISCOVERED transient temperature/heat flux measurements
- INCORPORATED PXI Platform for real-time system
- ACCELERATED development to capitalize on field testing

## NEXT STEP:

- Ruggedness for safety application
- Explore transient measurement applications
- Partner for combustion engine and aerospace
- Field Testing Field



# The Great American “*sound and temperature*” Road Show

Deploy solutions at various research facilities

Success in these ventures will give us a good baseline to build a market as well as validate our technology

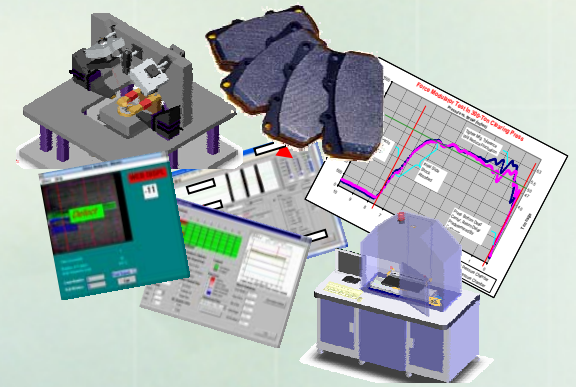
We are very confident in our technology, but have limited contacts to deploy and test.

Non-destructive nature of the measurements allows for easy implementation without disruption to ongoing tests.



# *Ultrasonic Temperature and Heat Flux Sensor Technology*

## Thanks For Listening!



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