Design & Flight Testing of a Mortar Deployed Video Imager
4/10/01, NDIA PRES.

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TOM HARKINS - IMAGE ANALYSIS
SAM PEREZ / DIANE WAGNER / EUGENE SCHLENK - PM MORTAR SYSTEMS, ARDEC - MORTAR PARTS, DWGS, & INFO.
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• **OBJECTIVES:** DESIGN & DEMONSTRATE A GUN-HARDENED, “WIRELESS”, DIGITALLY-ENCRYPTABLE, IMAGER SYSTEM (<$10k/imager)
• **SUPPORTS:** ARDEC QUICKLOOK STO.
• **PLAN:** APPLY COTS VIDEO AND XMTR TECHNOLOGIES & INTEGRATE INTO A MODIFIED XM930 120mm MORTAR SUBMUNITION.
• **CONCLUSIONS:** SUCCESSFULLY FLIGHT-TESTED IMAGER MORTAR TO ~2000 G’S, PCZ #1.
• **LESSONS LEARNED:** IMAGERY MUST BE ANALYZED TO DETERMINE USAGE, TLE, BDA, etc. & TO DETERMINE REQ’D. IMPROVEMENTS.
Design & Flight Testing of a Mortar Deployed Video Imager

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FLIGHT TEST PLATFORM – REQ.’D MODS.

1. REPLACED CANDLE LOADING ASSY. W/ IMAGER (3.68” dia. X 5.24” L)

2. REPLACED FIBERBOARD BAFFLE PLATE (.25” t) WITH STEEL PUSHER PLATE

3. TRIMMED REAR BODY JOINT EDGE (~ .160”)
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IMAGER SUB-MUNITION CONCEPT & DESIGN

- Pusher Plate, Mat: Stainless Steel, 17-4PH
- O-Ring, Mat: Neoprene
- CCD Camera Module
- Transmitter/Camera Plate
- DB-9 Connector
- Batteries
- Battery/Turn-On Switch
- Power Distribution PWB
- Encoder PWB
- Base Plate
- Parachute Swivel
- Bearing Cage
- Housing, Mat: 7075-T6 Aluminum
- S-Band Transmitting Antenna
- Battery/Encoder Holder, Mat: ABS Plastic, Rapid Prototype
# Design & Flight Testing of a Mortar Deployed Video Imager

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<table>
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<tr>
<th>IMAGER BOM (NON-PROD. VERSION)</th>
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<tr>
<td>COTS CCD CAMERA</td>
<td>120</td>
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<tr>
<td>COTS VIDEO COMPRESSION ENCODER</td>
<td>2880</td>
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<tr>
<td>COTS XMTR, S-BAND, HI-G Q’D.</td>
<td>4000</td>
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<td>COTS ANTENNA, S-BAND</td>
<td>1525</td>
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<td>COTS BATTERIES, NICAD</td>
<td>50</td>
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<td><strong>PER UNIT COST (W/O NRE &amp; LABOR COSTS)</strong></td>
<td><strong>8575</strong></td>
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KEY DESIGN FEATURES....

- O-RING SEAL FOR INTERNAL EXPULSION GAS RESISTANCE
- IMAGER FOV
- ENCAPSULATE INTERIOR VOL. & COMPS. TO SHOCK-HARDEN
- THRU-MORTAR-BODY MAN. TURN-ON SWITCH
- INTERFACE TO EXISTING PARACHUTE
- INTEGRATE WRAP-AROUND ANTENNA
GROUND SHOCK TABLE TESTING OF IMAGER COMPONENTS…

- Camera to 40k-G peak
- Encoder to 10k-G peak
- Power dist. PWB to 13k-G peak

Diagram showing test setup with labels for camera module, table base plate, launch direction, and shock table fixture.
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ASSEMBLE....

ABS PLASTIC RP
BATT+ENCD’R+
PWR BOARD
HOLDER
(used CAE art-to-
part technologies,
FDM)

ENCD’R BRD
(OEM as is)

4X NICAD BATTS,
(20min. total discharge time)

PWR BRD

ENCAPSULATE....
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IMAGER SYSTEM

IMAGER

- DATA
- AUDIO
- PCM
- 5 VDC

TELEMETRY TRANSMITTER

ENCODER CONTROL EIA232

ENERDYNE ENC210A4

* Or Other NTSC or EIA170 Video Sources

GROUND-STATION

- TELEMETRY RECEIVER
- AUDIO
- PCM

DEC210R5 DECODER WITH BIT SYNCHRONIZER

VIDEO MONITOR

EIA232

DECODER CONTROL TERMINAL
IMAGER GROUND STATION

- S-BAND TELEMETRY ANTENNA
- S-BAND TELEMETRY RECEIVER W/ PHASE MODULATION "PLUG-IN"
- S-VHS PLAYER RECORDER
- CUSTOM PC104 COMPUTER WITH LCD DISPLAY, 16-BIT TYPICAL ENCODER CONTROL INTERFACE, & PC/RETA VIDEO DISPLAY & "FRAME GRABBER"
- DE C210CR5 DECODER
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DESIGNED & BUILT A LOW-COST, IN-LAB MORTAR BODY ASSEMBLY FIXTURE
• FOR BATTERY TURN-ON SW. PORT INSTALL.
• IMAGER INSTALLATION
• MORTAR BODY SHEAR PIN INSERTION

[Diagram and instructions for assembling and using the mortar body fixture]
VERIFIED HSG. & PLATE STRUCTURAL INTEGRITY AND MORTAR EXPULSION DYNAMICS WITH FEA

Max. dynamic defl. of pusher plate is less than .030" & will not contact camera lens or xmtr

DYNAMIC FEA:
- AXI-SYM. HSG & PUSHER PLATE MODEL USING QUADRILATERAL ELEMENTS
- LINEAR MAT.’L PROPS USED
- TRANSIENT EXPULSION OVERPRESSURE APPLIED TO PUSHER PLATE PLUS LAUNCHING LOAD
- MORTAR BODY HALVES MODELED USING HI-DENSITY ELEMENTS & CONTACT ELEMENTS
- BIRTH & DEATH OPTION DISPL. CONSTRAINTS USED TO MODEL EXPULSION INITIATION

10 k-g’s Launch acceleration

Steel pusher plate & 7075-t6 aluminum hsg. stresses are well below yield

Von Mises
- 63370
- 54317
- 45264
- 36211
- 27158
- 18106
- 9052.8
- 0

Steel pusher plate & 7075-t6 aluminum hsg. stresses are well below yield
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FLIGHT TESTED MOCKUP IMAGER ROUNDS
- INSURED EXPULSION & CHUTE DEPLOYMENT
- VERIFIED INTEGRITY OF HOUSING & FEA PREDICTIONS
- VERIFIED INTEGRITY ANTENNA
- VERIFIED O-RING SEAL
- VERIFIED PUSHER PLATE DYNAMICS

120mm MORTARS...WARMERS & MOCKUP IMAGER ROUND

RECOVERED MORTAR BODY HALVES AND MOCKUP IMAGER

MINIMAL RESIDUE DEPOSITED BY EXPUL. CHARGE GAS BLOW-BY...
CAMERA LENS SHOULD BE O.K.

CONTACT PINS WERE NOT CONTACTED BY PUSHER PLATE DURING EXPULSION...
CAMERA & XMTR SHOULD BE O.K.
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FLIGHT TESTING OF IMAGER MORTAR ROUND

• PROVED IMAGER ROBUSTNESS TO TYPICAL MORTAR GUN-LAUNCHING LOADS (1500-3000 g’s)…MINOR ANTENNA DAMAGE SUSTAINED IN SHOT

• IMAGER RECOVERED AND WAS REUSEABLE

• 5 FR/SEC (@1.25MBITS/SEC.) ACQUIRED FOR 90 SEC. DECENT FROM EXPULSION @ 1400’ ALTITUDE; INITIAL CAMERA FOV @ EXPULSION = 1616’ x 1553’, i.e. ~ 1m x 1m = 1 pixel

20 sec. of video from imager

Created with Personal AVI Editor Shareware version

20 sec. of video of decending imager from camcorder on ground
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BP's Range is limited to Prop. Zone 3 @ Q.E. of 85-deg. for XM930 Mortar, 10k-ft ceiling

- TM VAN TO GUN-Z1 = 3300' GROUND RANGE
- TM VAN TO IMAGER SUBMUNITION = 6000' (mockup); 4700' (imager) GROUND RANGE
- TARGET1 AREA IS WHERE MORTAR BODY HALVES FELL
- MORTAR EXPULSION RANGE IS 4700' FROM TM VAN; EXPULSION ALTITUDE = 1400'
SUMMARY

- 120mm MORTAR IMAGER CONCEPT PROVEN
- IMAGER GUN-HARDENED TO ~2000 gs
- IMAGER LESSONS LEARNED & FUTURE...
  - IMAGE QUALITY & USE MUST BE ADDRESSED
  - ANTENNA RECEPTION ISSUES [VIDEO DROP-OUTS] MUST BE ADDRESSED
  - INTEGRATE NEW HSTSS XMTR, INERTIAL SENSORS, SIG. COND., ADDITIONAL PCM ENCODER, NEW BATTERY, & GPS REC’R...SENSORS TELL WHERE IMAGER IS LOOKING
  - ADDITION OF INTERNAL G-SWITCH TURN-ON FEATURE; REDUCES BATTERY VOL., ELIMINATES GUNNER TASK.