APPENDIX 3.G-

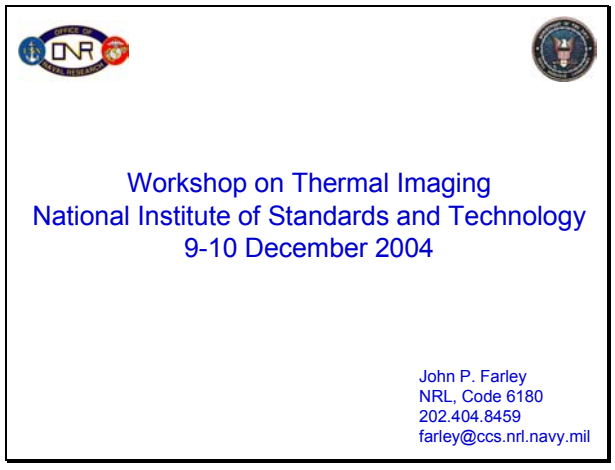
NRL Thermal Imaging Review

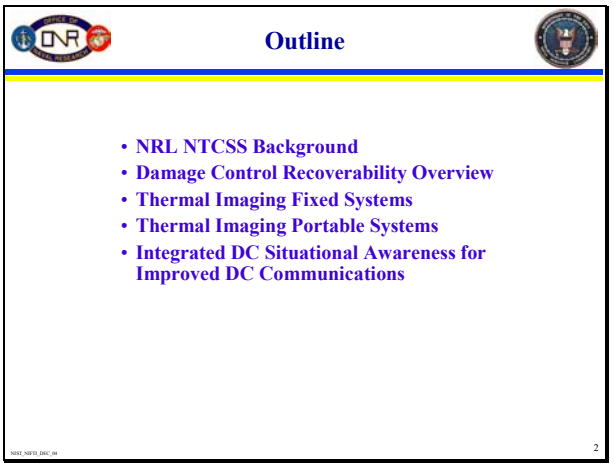
John P. Farley, Navy Safety and Survivability, Naval Research Laboratory, Washington DC

The Naval Research Laboratory's Navy Technology Center for Safety and Survivability reviewed the Navy's efforts related to developing the use of thermal imaging technologies for naval combatants. The presentation provided information on the Navy's full-scale RDT&E test ship, ex-USS SHADWELL, which is a major facility at the Naval Research Laboratory for the protection of life and property, under the auspices of the Navy Technology Center for Safety and Survivability. The presentation included insight into the on-going program efforts for developing both fixed and portable thermal imaging technologies, which included work related to the DD(X) Autonomic Fire Suppression System (AFSS), Flight Deck Engineering Development Model (EDM) Flight Deck testing, the CVN 21 Hangar Bay testing, and the development of Machine Vision technologies (Near IR capabilities). The presentation also included a Navy perspective for future hand held/hands-free portable thermal imaging requirements.

Biography:
Mr. John Farley is a Fire Test Engineer for the Naval Research Laboratory and is the Project Officer for the ex-USS SHADWELL responsible for testing and development of shipboard fire protection technology, procedures, and policy for the US Navy.

Security Classification of the Brief: UNCLASSIFIED





Navy Technology Center for Safety & Survivability

- Dedicated to studies on active & passive fire protection, flooding, and chemical defense
- Realistic, time-critical scientific measurement, modeling, and performance analysis
  - Sensors, materials, equipment, personnel, doctrine, tactics, and command & control
- Application of basic and theoretical research and development
  - Fire models, predictive tools, agents, sensors, systems, and technology
- Evaluation of hardware/software concepts and experiments with users
  - Systems Commands, OPNAV staffs, Navy Warfare Centers, Navy Laboratories, Fleet Commands, Training communities

Damage Control Recoverability Overview

Development of DC-ARM Technologies (Supervisory Control, Early Warning Fire Detection System, Distributed water mist, Smart Valves

Transitioning Damage Control - Automation for Reduced Manning (DC-ARM) technologies into DD(X) AFSS EDM with the addition of PDA cooling

Technologies needed to close Survivability Recoverability Gap
- Integrated DC communications
- Passive fire protection
- Enhanced magazine fire protection system
- Universal water mist system

'97 '98 '99 '00 '01 '02 '03 '04 '05 '06 '07

LPD-17 Water mist & Smoke Ejection System (SES) Design Validation

LPD-17 Water mist and SES Installation

Development of FFP FNC Advanced Damage Control (ADC) Technologies including Hybrid Water Mist and Machine Vision

ONR Thrust
- Water Mist optimization
- Blast Mitigation
- Aerosol Dynamics
- Network Fire and Smoke Simulator

Thermal Imaging Fixed System Initiatives

Multi-Sensory Video Image Detection System for Situational Awareness

Intelligent Machine Vision Algorithms

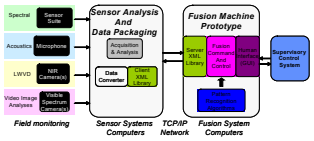
Sensor Fusion Processing & Monitoring

Operational Capability: Under the ONR program, NRL is developing a damage control detection system using multisensory, multivariate methods and machine vision for motion and shape recognition, to detect flaming and smoldering fires, pipe and hull ruptures, and flooding. The modular architectural design allows this system to be expanded to new and different missions of interest to the Department of Defense and homeland security. Data fusion methods can be modified to provide surveillance and detection of these events. This technology is very attractive for mass transit systems because it combines surveillance with fire detection.

Performance Targets: The system will detect objects, unusual human behaviors, and unusual events, including fire detection. The system will monitor events, provide pre-alarm and alarm conditions for unusual events, store, archive and index alarms for easy recall.

Cost of Ownership: Cost is reduced by the reduced manning requirements, use of existing surveillance cameras and dual use of hardware for many functions.

Approach:
Use an innovative architectural design for a prototype real-time remote detection system based on existing and emerging technology. System will be modular and expandable using visible and near-infrared images, spectral and acoustic sensors with analysis by machine vision and pattern recognition. Data fusion and analysis methods will be configured for sensitive and selective early event recognition. Uses current advances in commercial video image fire detection.



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Sponsor: Office of Naval Research

Spectral-Based Volume Sensor (SBVS)

Strategy:
- Optical detection of fire, smoke, and other hazards
  - Detection methods outside visible spectral region
  - Potential security applications
- Integrate with and augment video/machine vision
- Match spectral window for detection to fire emission
- Limited to economical and reliable methods/devices

Approach:

Long wavelength video detection (LWVD):
- Nightvision:
  - Use extended red/NIR sensitivity of standard CCDs
  - Long wavelength filter suppresses visible image for higher contrast
- Augment visible cameras:
  - Detects reflected flame & hot objects
  - Modest thermal imaging

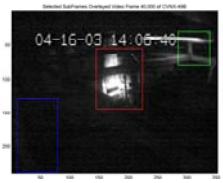
Discreet spectral sensors – SBVS Testbed
- COTS (IR/UV) detectors and novel in-house sensors
- In-house analysis of emission bands:
  - Standard (UV, IR)
  - Novel (vis/NIR photodiodes, 589 nm, 766 nm, NIR)

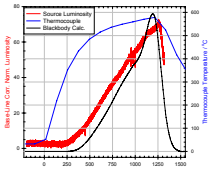
Long wavelength video detection

SBVS Testbed

LWVD Recent Progress

Long wavelength video detection (LWVD):
- Nightvision detection utilizing extended red/NIR sensitivity of standard CCDs
- Detects reflected flame emission and hot objects/bulkheads:
  - Filtered nightvision cameras and NRL luminosity algorithm
  - Minimum temperature for hot object detection ~ 400°C
- Develop LWVD system for integration with data fusion / prototype
  - Stand alone implementation with multilevel output
  - Fusion system compatible output





VS1-24 Non-FOV Fire Source

Regular Video

Nightvision Video

DD(X) Flight Deck EDM Tests

Landing area fire suppression design concepts:

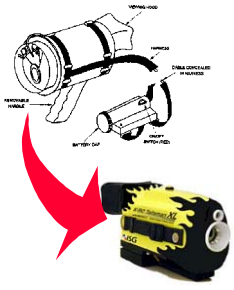
- AFFF tele-robotic firefighting nozzles (TFNs)
- AFFF deck nozzles
- AFFF hose reel stations
- Multipurpose Aviation Decking Material (MADMAT)
- Enhanced visual sensors (IR and visual cameras)

EDM Configuration – IR Cameras

- 2 Camera sets in EDM.
- IR and Visual Cameras
- Tilt / Pan / Zoom
- Multiple (4) windows on console screen in HCS.
- Cameras provide ability to control TFN operation both locally and remotely

Thermal Imaging Portable Systems

Portable NFTI Background



- Need identified during British Falklands War
- Initial technology based on valve tube (Vidicon, Pedican, Hevicon)
- Significant size/weight and maintenance issues
- Newer technologies have moved to solid state (micro bolometer sensor)

Future Portable NFTI Requirements

- Hands-free vs hand-held capability
- Wireless interface
- Ability to work in high humidity environments
- Tolerance to high heat environments
- Ability to distribute IR images

Integrated DC Situational Awareness for Improved DC Communications

•Based on actual shipboard casualties and 15 years of real scale tests with Fleet participants, communications continues to be the number one Damage Control issue which impedes DC performance
•Current DC Communications are inadequate and not integrated with DC systems and sensors

- Determine the efficacy of wearable computer/PDA for real-time DC communications
- Investigate the opportunities of integrating DC sensors and or machine vision technologies for enhanced DC communications network
- Build on NAVSEA/BIW RF network initiatives to provide a damage tolerant and compatible DC communications system
- Scope - transform existing stovepipe (stand alone) technologies into a fully integrated communications system
- **Fleet Number One Priority for Damage Control**