



Developing New NFPA Standards: Initial Working Group Phase



**Larry Konsin, Manager, Customer Development, MSA /
Working Group Chair, NFPA 1801 TIC Standard**

Developing New NFPA Standards: Initial Working Group Phase

December 9 - 10, 2004 – Industry Meeting

NIST Workshop on Thermal Imaging Research Needs



Meet the workshop participants, shown here in the long wavelength infrared (above) and visible (below) spectra.



Goal of the NIST Workshop:

- to identify and define research needs of the user community
- develop performance standards that consider interoperability and integration
- demonstrate performance metrics

Thermal Imaging Cameras - 2004



Perspectives from TIC Manufactures

NIST Workshop on Thermal Imaging Research Needs

Larry Kossin
American Council For Thermal Imaging (ACTI)
December 9, 2004

ACTI is comprised of companies who design, manufacture and market infrared sensors and thermal imaging systems for commercial applications.

TIC Manufacturers Perspective Background

NIST Workshop on Thermal Imaging Research Needs

Purpose of the NIST Workshop:

- Assess Fire Service/First Responder (FS/FR) needs and effectiveness
- through sensitive development of performance metrics and reporting practices with regard to provision of thermal imaging technology.

Goal of the NIST Workshop:

- Identify barriers that impede advance in the application of TIC technology
- with follow-on efforts from government agencies, the response community, industry, and academia to:
 - Identify and define research needs of the user community
 - develop performance standards that consider reliability and integration
 - demstrate performance metrics.

TIC Manufacturers Perspective Background

NIST Workshop on Thermal Imaging Research Needs

NIST suggestions for TIC Manufacturers Presentations:

1. What are the technological trade-offs that are faced in producing a TIC?
2. What performance testing is done and how can it improve?
3. What technological advances are on the horizon?
4. What performance standards are most important?
5. What are the most critical issues in establishing performance standards?

Possible Working Session Topics for group discussions:

- What are the prioritized research needs for thermal imaging for FS/FR?
- What performance metrics are needed?
- How do they differ from current methods?
- What standards are needed?
- What technological advances are needed?

1. What are the technological trade-offs that are faced in producing a TIC?

NIST Workshop on Thermal Imaging Research Needs

- Generally, infrared (IR) sensor design is driven by military and large commercial market applications, not Fire Service/First Responder (FS/FR) applications. FS/FR TICs are not produced in volume large enough to justify the cost of an application specific sensor. TIC Manufacturers, working with the Sensor Manufacturers, must find ways to enable the sensors to perform and survive the rigors of the "world's harshest environment" which include:
 - High external heat, open flame, explosive and IED environments
 - Shock (impact, vibration, corrosion, and abrasion (display lens))
 - water immersion, water spray
 - particulate resistance
 - high thermal temperature
 - radio frequency interference (RFI)

Larry Kossin, American Council for Thermal Imaging

Overview of NIST Thermal Imager Project

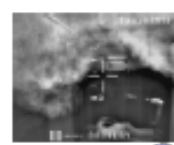


Francine Amon
Building and Fire Research Laboratory
National Institute of Standards and Technology

NIST
Funded in part by the United States Fire Administration

Outline

- Performance metrics
 - Categories, types
 - Combinators & modifications
- First Responder Conditions
- Testing Approach
 - Full-scale
 - Bench-scale
- Results
- Summary



Types of Performance Metrics

- Display and Button Conformity
 - Temperature bar or indicator
 - "EI" symbol
 - Use of color
- Design/Integrity Requirements
 - Immersion, Impact, heat, vibration, etc...
 - Power life, alarms, intrinsic safety
 - RFI/EMF interference
- How do you know if it passes a test?
 - Optical performance

Conventional Opto-Electric Performance Metrics

Gain Response & Noise	Geometric Resolution	Overall Image Quality	Observer Response
S/N, FL, DR, PRM	Field of View, FOV & FOV	Image Detail, Contrast, Resolution	Min. Res. Temp. Diff. (MRTD)
Temporal NEDT & NPSD	DR Response (DRP)	Visual Temporal Noise	Auto-MRTD (AV), Other Tests
Signal NEDT & NPSD	Integrated Energy (IE)	Visual Spatial Noise	Min. Det. Temp. Diff. (MDTD)
DR Noise (NEDT)	Colorbar Transfer (CTR)	Resolution & Contrast	MRTD Offset
Above Test vs. Background Temp.	Modulation Transfer (MTF)	Residual non-uniformity	
BER, NPSD, NRP, D*	Dilatation (DSDT) Storage Alga	Red pixel transfer	

Ref: J. B. Proceedings of SPIE, 2000

Francine Amon, Building and Fire Research Laboratory, NIST

NIST Workshop on Thermal Imaging Research Needs for First Responders

Perspectives from a Detector Manufacturer

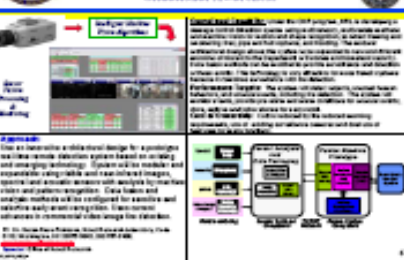
Tim McCaffrey
Raytheon Commercial Infrared
972-344-5363

Perspectives from a Detector Manufacturer

- Review the differences between the various detector technologies used in thermal imaged/IR cameras developed for first responders
- How the resulting images differ among detectors
- Technological advances in detectors; envision the future
- Performance standards that are important for the development of this technology

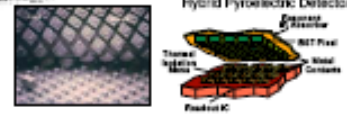
Thermal Imaging Fired System Initiatives

Multi-Sensory Video Image Detection System for Situational Awareness



Detector Technologies

Hybrid Pyroelectric Detector

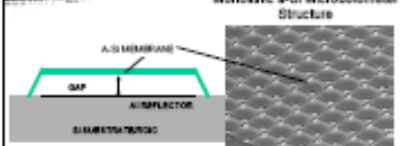


Product IC

- DR > 500 years
- DR > 40 dB peak
- DR > 1000 optical mV/lux
- Polysilicon thermal isolation process
- Simple integration to IC
- Highly sensitive to IR
- Highly sensitive to IR
- Highly sensitive to IR

Detector Technologies

Monolithic a-Si Microbolometer Structure



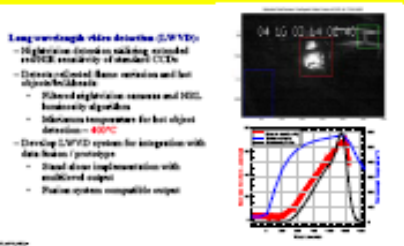
- Low Thermal mass (resistor)
- High Thermal isolation
- Short thermal time constant: less than a frame
- Resonant cavity design for High IR Absorptance
- High resistance (1 TΩ) DC Detector (NED)
- On-chip micropillar process

Tim McCaffrey, Raytheon Commercial Infrared

Spectral-Based Volume Sensor (SBVS)



LWVD Recent Progress



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

Workshop on Thermal Imaging Research and Performance Standards Needs for First Responders

Building and Fire Research Laboratory (BFRL)
National Institute of Standards and Technology (NIST)

December 9 and 10, 2004



Workshop Objectives

- identify thermal imaging needs of first responders, with an emphasis on standards.
- create a research agenda and a roadmap for continued development of thermal imaging technology.
- present and obtain feedback on draft performance metrics developed at NIST.

NIST Workshop on Thermal Imaging Research Needs for First Responders (2004)

The Firefighters Challenge

Often times the biggest challenges facing a firefighter as the end user is not the heat and smoke.

International Association of Fire Chiefs

It's Often the Gear Itself

International Association of Fire Chiefs

Why standards?

- improve product effectiveness
- may lead to increased demand
- add-test testing being conducted by agencies
 - expensive to develop
 - may raise buy elements
- **improve safety** for first responders and the public

Standards Organizations

- advocating scientifically-based consensus codes and standards
- American Society for Testing and Materials (ASTM)
- National Fire Protection Association (NFPA)

NIST Workshop on Thermal Imaging Research Needs for First Responders (2004)

Anthony Hamins, Building and Fire Research Laboratory, NIST

ASTM Standards

- Test methods: E 1933-99a, E 1543-00, E-1862-97, E-1897-97
- ASTM standards do not address typical use conditions - such as a fire

ASTM International

NIST Workshop on Thermal Imaging Research Needs for First Responders (2004)

As Christmas Approaches - Thermal Imager Wish List

- Color Display
- Brighter
- Pattern Alerting
- Integrated

International Association of Fire Chiefs

As Christmas Approaches - Thermal Imager Wish List

- Heads-up display
- Rapid on/off Capability
- Location Transmitter
- Lifetime resistance free battery

International Association of Fire Chiefs

Brian Duggan, Fire Chief, City of Northampton Fire Department, MA

The sizes, they are a changing

Santa Rosa Fire

Low Cost, we're getting closer

Santa Rosa Fire

TEMP BATT

\$75,000.00 The department was had a camera for a year and would like to have them on every piece of the equipment, but the cost is prohibitive. **TEMP BATT** following the save of 2 firefighters in a house fire incident.

\$25,000.00

\$16,000.00

\$12,000.00

\$ 8,000.00

OK, so when do I hear \$2000.00 or less? Now we are beginning to talk about 1 for every riding position. We really will have the ability to see in the fire environment. It becomes another piece of PERSONAL protective equipment.

BATTERY

Switch Operation

- Press to Turn On
- Release to Turn Off
- Hold Down To Turn Off
- Press to Turn Off
- Release for Stand By
- Press for Stand By

SAFE-IR

Switches/Functions

Match the correct switch color with the Function

a) On / Off	f) 2x Zoom
b) Stand By	g) Manual Shutter
c) Video Xmitt	h) A,B
d) Video Overlay	i) A,B,C,G
e) Image Capture	j) A,E,F

SAFE-IR

Did I mention rugged?

Santa Rosa Fire

Let's review this again

Santa Rosa Fire

- Low cost
- Light weight
- High Quality Image
- Hands free - Helmet or face piece mount
- Easy to interchange between users
- Firefighter Friendly (intuitive)
- Low maintenance - Very rugged
- Unfailingly reliable (Mission critical)
- Long battery life (low cost replacements)
- Lifetime unlimited warranty
- Certification and Testing (NFPA)

Bruce Varner, Fire Chief, City of Santa Rosa Fire Department, CA

ICONS & INDICATORS

Standards MUST establish
1 Primary Indicator for each purpose!

NEED TO BE CONSISTANT & COMPATIBLE WITH PPE TODAY FIREFIGHTERS USING DIFFERENT TI

MAKES
+MODELS
+MUTUAL AID

Confusion, Inconsistency = Rejection!

SAFE-IR

Micro Bolometer "MODE" INDICATOR

SAFE-IR

Bob Athanas, President, SAFE-IR, Inc.



Chief Brian Duggan representing IAFC

1. Initially search/rescue tool - now indispensable tool – multiple applications.
2. Battery life issue – failures after doing everything you were to do
3. Chargers need to be just as reliable as a good battery system
4. TIC down – must have a fall back – trained on what to do

Chief Bruce Varner, Santa Rosa FD



1. Hands free – helmet or facepiece mount
2. Low cost - light weight - high quality image
3. Easy to interchange between users
4. Firefighter friendly - intuitive
5. Low maintenance - very very rugged
6. Unfailingly reliable – mission critical
7. Long battery life – low cost replacements
8. Lifetime unlimited warranty
9. Certification and testing - NFPA

Firefighter Bob Athanas, Special Operation FDNY



1. Inconsistency with cameras because of lack of standards
2. Training issues – under utilization of the tool
3. There has to be a way to simplify TICs for the end user
4. Simplicity + consistency = safety
5. Inadequate, inconsistent and inaccurate information
6. Make + models + mutual aid = confusion, inconsistency = rejection
7. Different color buttons – match the colors with the features
8. Temperature and color – What does it mean?
9. Bob has used TIC since 1991

Developing New NFPA Standards: Initial Working Group Phase

May 19, 2005 – Initial Meeting

Fire Service TIC Operational Standards Working Group

Fire Service TIC Operational Standard Working Group

Meeting 1: May 19, 2005 Meeting, Jersey City, NJ

In attendance:

Bob Athanas, FDNY
Bob Knabbe, FDNY
Scott Law, ISG
David Little, ISG
Larry Konsin, MSA (Chair)

Summary of Progress:

Standardized Graphics Concept:

Thermal Imaging Cameras (TICs) shall default to a standard graphical user interface (GUI) so that any user trained on a specific brand of TIC could effectively activate and operate any other brand of TIC through the same GUI.

In addition to the default GUI, TIC manufacturers may allow users to manually activate additional features and functions that are not contained in this TIC Operational Standard, through a user-selectable GUI. The user-selectable GUI may also be configurable by the user.

The TIC shall default to the standard GUI at:

1. power-off
2. manual deactivation of the user-selectable GUI

The default GUI is defined as a standardized set of informational alpha numerics and/or symbols that provide information on the status, operation, condition or use of the TIC.

The user-selectable GUI is defined as unique set of informational alpha numerics and/or symbols that provide information on the non-standard features and functions of the TIC. There shall be indication of the status, operation, condition and use of those non-standard features and functions through the user-selectable GUI.

The GUI area may consist of both the TIC display, and a one inch tall area that runs horizontally directly above and below the display, being on the same plane as the display, for effortless viewing by the user.

Default GUI Layout Concept:

On the TIC display, the GUI area shall consist of three vertical columns, each consisting of one-third of the total area of the display. In addition, the one inch tall area that runs directly above and below the display, being on the same plane as the display, is considered part of each of the three columns. Each of the three columns shall contain specific, assigned TIC operational information:

(Note: Each Column item is listed in order from top to bottom)

1. Left Column Area is for "Additional Information" indicators:
 - a. Mode Indicator (display)
 - b. Shutter Indicator (display)
 - c. Transmitter Indicator (display)
 - d. Video or Image Capture Indicator (display)
 - d. Additional room for new indicators (display)
 - e. Sensor Over Temp Warning (below the display)
2. Center Column Area is for "Alarm" indicators:
 - a. Battery (above the display)
 - b. Temperature Measurement Crosshair (center of display)
 - c. Additional room for Battery Indicator (bottom of display)
 - d. Additional room for Battery Indicator (below the display)
 - e. Camera Status LED (below the display)
3. Right Column Area is for Temperature Sensing indicators:
 - a. Vertical Temperature Bar Graph (display)
 - b. Digital Temperature Measurement Readout (bottom of display)
 - c. Additional room for Battery Indicator (bottom of display)

Default GUI Indicators Concept:

Investigations of firefighter fatalities in structural fires show that most are caused by the firefighter not being aware of the changing fire environment and their personal situation. There is an opportunity for firefighters using thermal imaging cameras to better understand the changing fire environment in a new and better way. TIC operational color indicators could help firefighters better understand the often rapid changes in the firefighting environment and the status of their TIC. Simply put, green is good, yellow cautions, and red alarms.

The concept extends to the vertical temperature bar graph which will be broken down into three sections, with green at the bottom for cooler temperatures, yellow at cautious moderate heat and red at high heat.

NFPA 1801 TIC Operation

2 Operational Formats

TIC Basic

Default at Power On:

1. Black and White Imaging
2. Battery Indicator
3. Over-Temp Indicator
4. Camera On Indicator
5. Temperature Indicators
6. Heat Indicating Color
7. Heat Color Reference Bar

- Basic TIC training:

Firefighters with NFPA certified Basic TIC training can operate any other TIC regardless of brand, make or model. This allows for “mix and match” of TICs at a FD or Mutual Aid.

TIC Basic Plus

All 7 Basic functions Plus:

8. Additional functions
 - Image/Video Capture
 - User Selectable color settings
 9. Enhancements
 - Must follow Basic guidelines
 10. Innovations:
 - Firefighter Location
 - Identification/Accountability
 - Text Messaging, Information
 - Distance Finder, Gas Detect
- Basic Plus may be proprietary
- Advanced Department training
- To go back to Basic: Power Off/On

Restricted Access

Icons Description and Location

Additional Information



Low Sensitivity Mode Indicator



Basic Plus mode

Alarm and Operational Indicators



Over-Temp Indicator



Crosshairs



Battery Indicator

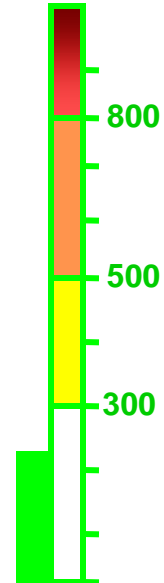
Battery Power Indicators

- 75% Power
- 50% Power
- 25% Power
- 5% Power



TIC On/Off Indicator

Temperature Sensing Indicators



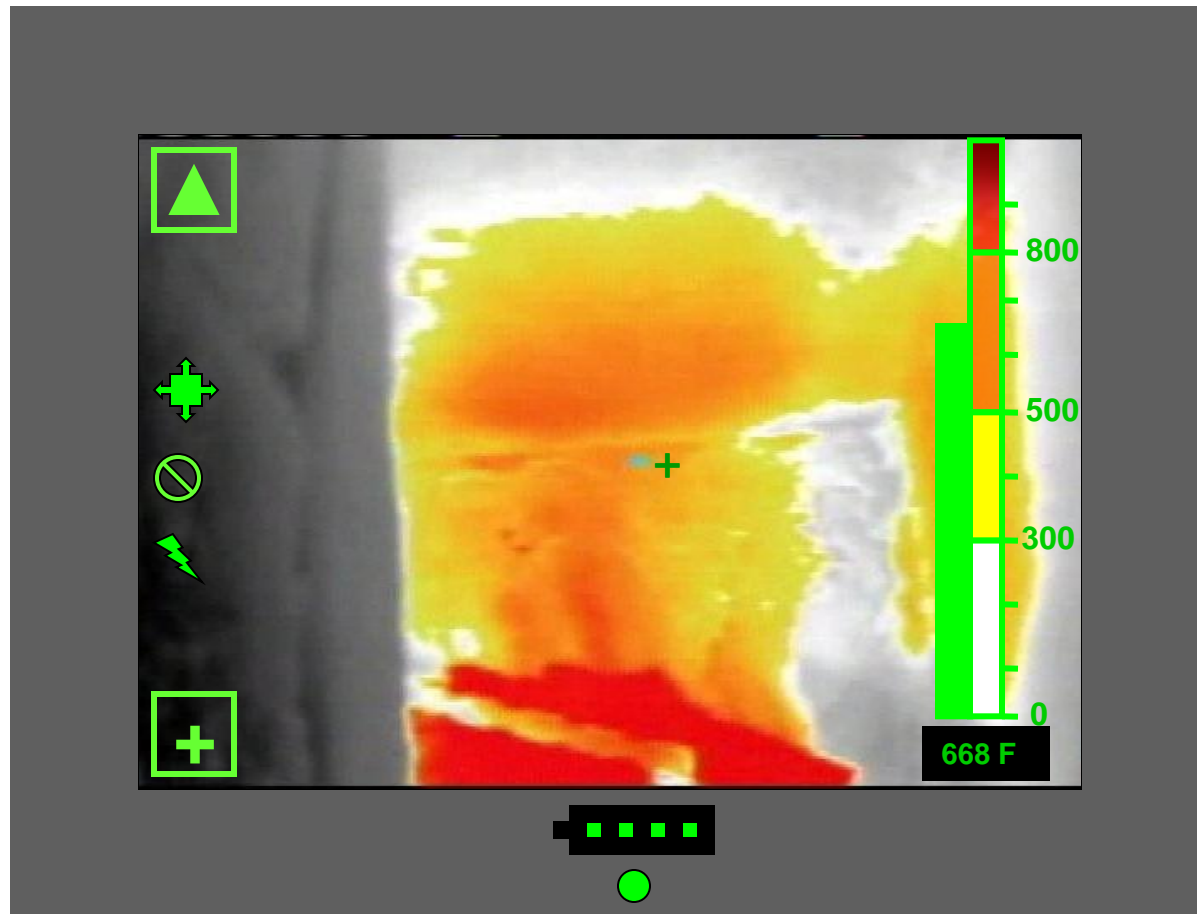
Temperature Bar and Heat Color Reference Bar

268 F

Temperature readout

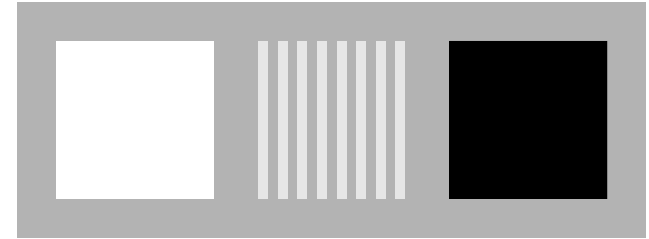
TIC Basic Plus with Optional feature Icons

Optional
Added
Features




Restricted Access

Performance Metrics Tests



- **Contrast & Spatial Resolution**
 - Contrast Transfer Function (CTF)
 - Random MTF target?
- **Thermal Sensitivity**
 - Perceivable thermal sensitivity viewing targets in various thermal classes
 - Camera itself exposed to elevated temperatures
- **Effective Temperature Range**
 - Determine the point at which the *displayed image* becomes saturated
 - Determine mode shift(s)
- **Image Uniformity**
 - Measure consistency of *displayed image*, given uniform input
- **Electro-Optical Transfer Function (EOTF)**
 - Relationship between displayed image and captured video output

Tests Needed for Different Classes of Fires

<u>Class</u>	Class I <i>(water, fog, or snow possible, minimal heat, smoke and flames)</i>	Class II <i>(elevated temperatures, water, dust, smoke and flames may be present)</i>	Class III <i>(high temperatures and smoke concentrations, flames, dust, and water are likely)</i>
<u>Activity</u>	<p style="text-align: center;">Hazmat Medical Motor vehicle accident Search</p>	<p style="text-align: center;">Overhaul Size up Tactics Forensics Preventative maintenance Search</p>	<p style="text-align: center;">Forensics Wildland fires Size up Tactics Communication Search</p>
<u>Proposed Metric/Test</u>	<p>Measure <u>thermal sensitivity</u> with surfaces having temperatures of 0 °C and 100 °C in FOV. Ambient temperature near 30 °C.</p> <p><u>Also</u>, measure the <u>contrast and spatial resolution</u> using a ΔT of 10 °C and surface temperatures near 30 °C.</p>	<p>Measure <u>thermal sensitivity</u> with surfaces having temperatures of 25 °C and 160 °C in FOV. Ambient temperature near 100 °C.</p> <p><u>Also</u>, test <u>effective temperature range</u> by measuring the largest ΔT at which the target pattern is discernible, one target temperature is set at 30°C.</p>	<p>Measure <u>thermal sensitivity</u> with surfaces having temperatures of 160 °C and 260 °C in FOV. Ambient temperature near 210 °C.</p> 

Developing New NFPA Standards: Initial Working Group Phase

September 29 - 30, 2006 – NFPA Meeting

NFPA Technical Committee on ESE Presentation

Fire Service Thermal Imaging Camera Standards Considerations

Presented to the:

**NFPA Technical Committee on
Electronic Safety Equipment**

29 – 30 September 2006

St. Louis, Missouri

By the:

Fire Service TIC Standard Working Group

Larry Konsin, Chair - Robert Athanas, Secretary

TIC Working Group Makeup

TIC Manufacturers

Bullard[®]
It's your life and you're worth it™

Drägersafety

e2v
e2v technologies

FireFLIR™

 **ISG**

ISI

MSA
The Safety Company

SCOTT®

TOTALFIREGROUP™
ADVANCED PERSONAL PROTECTION

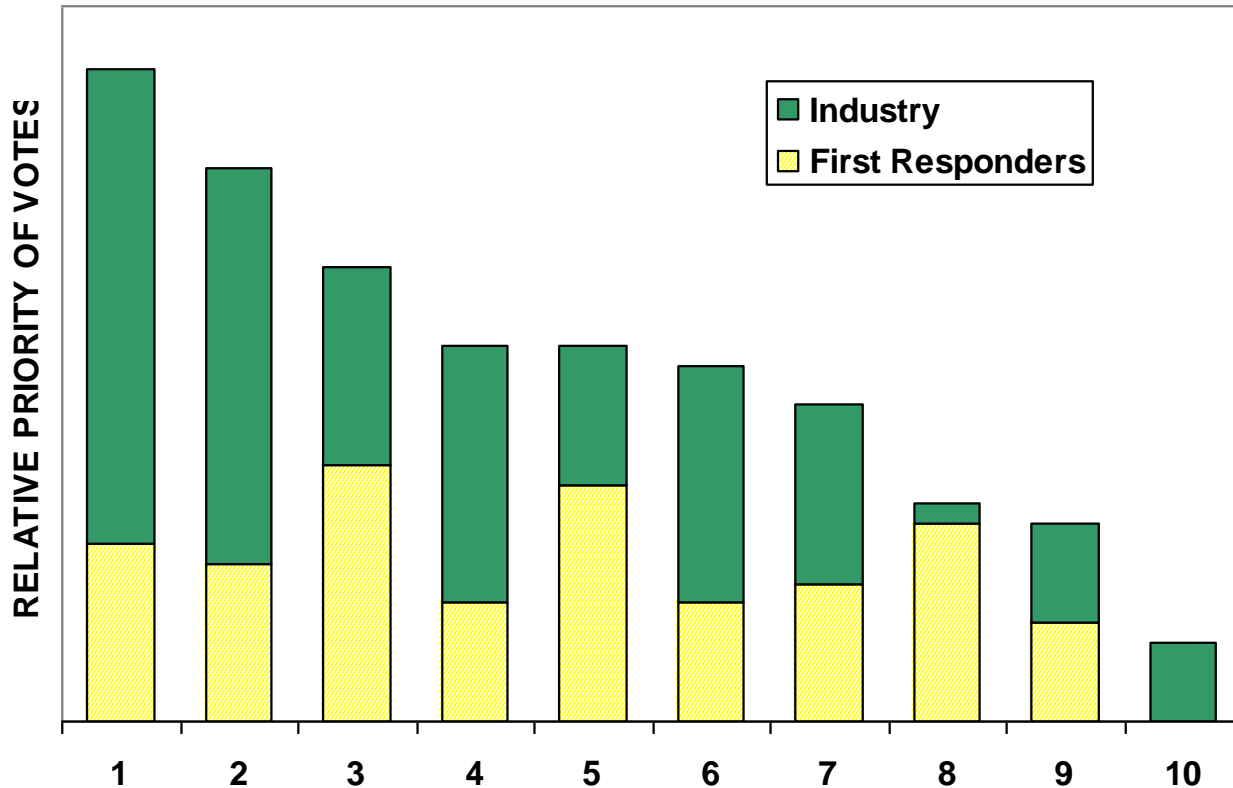
TIC Working Group Makeup

Technology, Training and Testing

BAE SYSTEMS



Overall Workshop Results



-
1. Image quality
 2. Durability
 3. Training and certification
 4. Establish test environments
 5. Human factor/ergonomic research
 6. Image display
 7. Battery and charger
 8. Reduction in imager cost
 9. Standard field target
 10. Imager self-test procedure

Full-Scale Tests (III)



Camera A



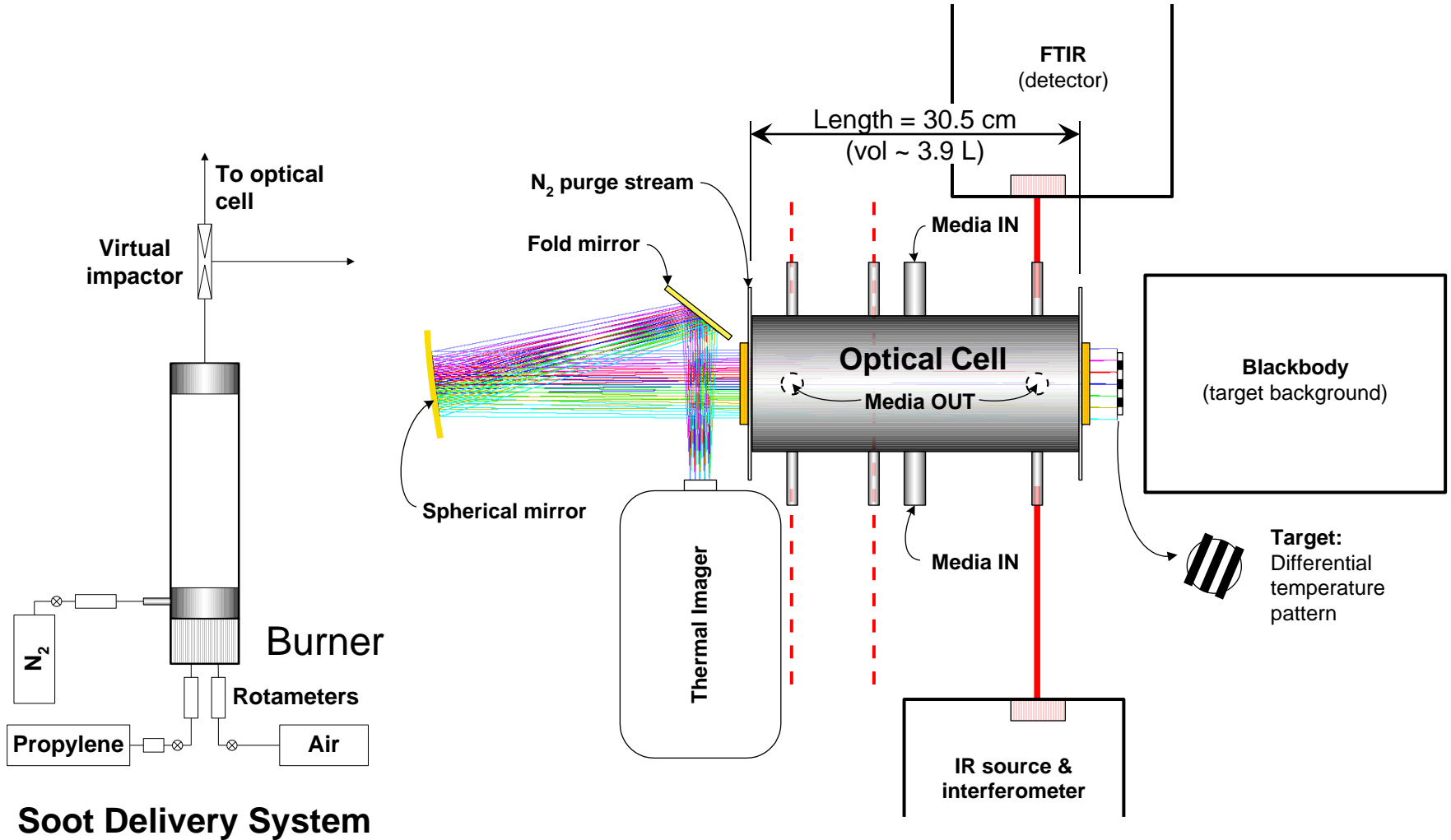
Camera B



Camera C

- **Hose stream tests: fog vs. jet**
- **Surfaces: wetted, initially dry, reflective**

Bench-Scale Testing Facilities (I)



What do you use your TIC for?

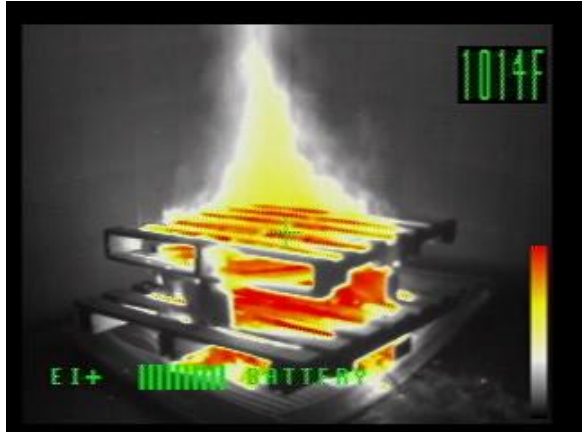
Apps in which TICs had been used

9 Q7

	COUNT	%	0	50	100
Size-up	63	33.9			
Search / Rescue	111	59.7			
Interior Attack	120	64.5			
Overhaul	165	88.7			
HazMat	14	7.5			
Exterior Search	52	28.0			
Wildland FF	7	3.8			
Non-labeled codes	0	0.0			
			0	50	100
186	Total Respondents				
532	Total Responses				

Bottom Line:

First Responders understand the basic uses of TICs. However, they remain materially underutilized.



Colorizing the image is important

Colorizing hot objects is important

(Percents based on responses)		TECHNOLOGY TYPES USED				
		BST	PEV	ASI	VOX	PBZR
Total Respondents	213 100.0	40 100.0	2 100.0	10 100.0	38 100.0	1 100.0
Strongly Agree	55 25.8	7 17.5		1 10.0	13 34.2	1 100.0
Somewhat Agree	53 24.9	10 25.0	1 50.0	2 20.0	13 34.2	
Neither	59 27.7	7 17.5		1 10.0	6 15.8	
Somewhat Disagree	21 9.9	9 22.5		5 50.0	3 7.9	
Strongly Disagree	25 11.7	7 17.5	1 50.0	1 10.0	3 7.9	
Mean	3.43	3.02	2.50	2.70	3.79	5.00
Median	3.53	3.07	3.50	2.30	4.04	4.75
Std Dev (n-1)	1.2927	1.3865	2.1213	1.2517	1.2337	0.0000
Standard Error	0.0886	0.2192	1.5000	0.3958	0.2001	0.0000
F (t if only 2 cols)		2.8497				
F Deg of freedom		4,	86			
F Probability		0.0198				

68.4%

40%

Bottom Line:

BST users, who typically do not have colorization, or temp dependent color, do not see the usefulness of color. VOx users, who have access to it, do.

The TIC Working Group Thanks You

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It's your life and you're worth it[™]

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e2v
e2v technologies

FireFLIR[™]

 **ISG**

ISI


communications

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The Safety Company

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Standards and Technology

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