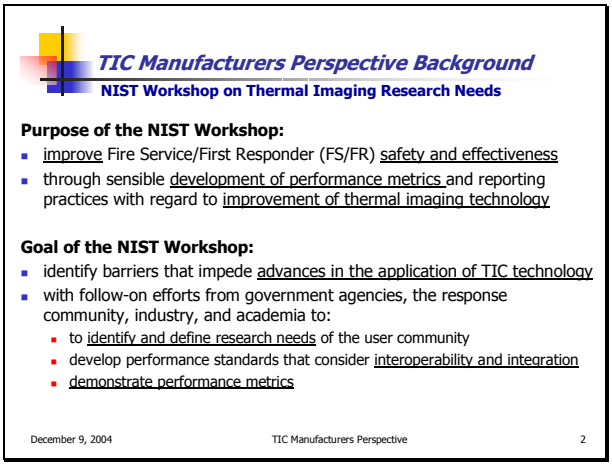
APPENDIX 3.E-

Perspectives from TIC Manufacturers

Larry Konsin, American Council for Thermal Imaging

TIC Manufacturers face many technological trade-offs in designing a Fire Service/First Responder (FS/FR) Thermal Imaging Camera (TIC). They find ways to keep infrared sensors operating in the harshest environments. The sensors are from sensor suppliers who design to military and large commercial requirements – generally not to FS/FR requirements. The FS/FR TIC market volume does not support an "applications specific sensor". Sensors are 70% of the cost of a TIC; therefore TIC Manufacturers do not have the flexibility to advance TIC technology much further than what the sensors offer. TIC Manufacturers performance test sensors to the specifications of the sensor supplier – and to the accepted standards of the FS/FR market. Currently, there are no NFPA TIC standards. Manufacturers anticipate new standards and are developing TICs to meet them. New standards have to balance the needs/wants of the FS/FR end-user with the limits of the sensor applications and cost. TIC Operational Standards are urgently needed to establish a common language and understanding for TIC safety and use. Over the years, TIC Manufacturers have meet the demands of the FS/FR market to eliminate "white out", measure temperature, reduce size/weight, improve imagery, reduce cost, and add value. The FS/FR market and NFPA, working together with the Manufacturers can continue to meet real needs in practical ways.



TIC Manufacturers Perspective Background

NIST Workshop on Thermal Imaging Research Needs

NIST suggestions for TIC Manufacturers Presentation:

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?

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- 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 volumes large enough to justify the cost of an applications 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 includes:
  - high external heat, open flame, explosive and IDLH environments
  - drop (impact), vibration, corrosion, and abrasion (display & lens)
  - water immersion, water spray
  - particulate resistance
  - high internal temperature
  - radio frequency interference (RFI)

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

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- Additional design responsibilities of the TIC Manufacturer include:
  - power supply reliability and performance, display synchronization
  - housing integrity, cable connection integrity
  - FCC and CE requirements,
  - electronic end-user warnings such as:
    - low power/battery remaining
    - high internal temperature
    - high scene temperature
- The technological trade-off is that by using available, lower cost non-FS/FR sensors (rather than an applications specific FS/FR sensor), the TIC Manufacturers must find ways to keep those sensors performing in environments that they were generally never designed to operate in. Also, when the FS/FRs conduct TIC evaluations, they expect TICs to perform beyond what is normally encountered in most FS/FR TIC applications – therefore pushing TIC Manufacturers to do even more .

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

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- The sensor accounts for 70% of the cost of a FS/FR TIC, delivering 50% of the perceived value to the end-user. TIC Manufacturers control the remaining 30% of the cost – delivering the remaining 50% of end-user perceived value.

Table 1: *Typical TIC Cost and Value to Fire Service/First Responder*

Components	Designer/Developer	% of Cost	% of Value
Infrared (IR) Sensor	sensor manufacturer	70%	50%
TIC Housing	TIC manufacturer	10%	30%
Support Electronics	TIC manufacturer	10%	10%
Display and Battery	3rd party suppliers	10%	10%

- Sensor costs heavily influence FS/FR TIC pricing. In the last 10 years, FS/FR TIC unit pricing has steadily declined by 65% from $25,000 to $9,000 largely due to sensor cost reductions.

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

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Table 2: *End-user TIC Price Reductions Since 1995*

Year of Intro	Format/FPA	End-user Price	Price Driver
1995	Helmet Mount 100x100	$25,000	First to market
1997	Hand Held 320x240	$18,000	Lower sensor cost
2001	Hand Held 160x120	$11,000	Lower sensor cost
2004	Hand Held 160x120	$ 9,000	Lower sensor cost

- The technological trade-off is that in the price-sensitive FS/FR market, TIC Manufacturers do not have the flexibility to advance TIC technology much further than what the sensor has to offer.
- Other non-custom components also help keep costs down but hinder technological advances and performance. Additionally, FS/FR TICs go through several component changes over the life of the product due to inconsistent availability of those components.

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

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- For example: display technology is largely controlled by the large electronics manufacturers who design and develop applications specific displays, amortizing their costs over very large volumes. TIC Manufacturers source the display production overruns and excess inventory of the large electronics manufacturers to keep costs down.
- Consequently, most TICs have gone through several display changes due to inconsistent availability. Often a display changes requires TIC housing mold changes and/or new electronics.

Table 3: *Additional FS/FR TIC Critical Non-Custom Components*

Component	Non-Custom Due To:	Critical Issue
Displays	low FS/FR volumes	Inconsistent supply, wrong specs
Connectors	low FS/FR volumes	Off-the-shelf supply limits design
Low $ Batteries	low FS/FR volumes	Batteries have special requirements
Low $ Optics	low FS/FR volumes	Needed for low cost TIC HUD design

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

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- Having to use off-the-shelf components, connectors, and switches somewhat limits optimization of a FS/FR design due to limited selection and availability.
- Most of these components are not designed to meet specific FS/FR requirements. Displays for example, have to be further protected from high heat since their 80°C (176°F) operating temperature limit is far below the extreme temperatures of the FS/FR market.
- The technological trade-off is again that in the price-sensitive FS/FR market, TIC Manufacturers generally do not have the flexibility to advance the technology beyond what the available components offer.

TIC Manufacturers Perspective Background

NIST Workshop on Thermal Imaging Research Needs

Purpose of the NIST Workshop:

- improve Fire Service/First Responder (FS/FR) safety and effectiveness
- through sensible development of performance metrics and reporting practices with regard to improvement of thermal imaging technology

Goal of the NIST Workshop:

- identify barriers that impede advances in the application of TIC technology
- with follow-on efforts from government agencies, the response community, industry, and academia to:
  - to identify and define research needs of the user community
  - develop performance standards that consider interoperability and integration
  - demonstrate performance metrics

2. What performance testing is done and how can it improve?

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Sensor Performance Testing

- FS/FR TIC performance testing is generally conducted on both the Sensor and the Total Package (which includes other features, functions, components and the TIC housing).
- TIC Manufacturers conduct sensor performance testing to ensure that the sensor conforms to the published specifications of the Sensor Manufacturer, and that the sensor meets generally accepted standards within the FS/FR market.
- Since TIC Manufacturers generally do not have much investment or involvement in the design and development of the sensors (for many of the reasons explained previously) they tend not to test beyond what they control.

2. What performance testing is done and how can it improve?

NIST Workshop on Thermal Imaging Research Needs

- Also, since sensors used in FS/FR TICs have somewhat similar operational and performance characteristics, there are few additional sensor performance characteristics for the TIC Manufacturers to test.
- Similarly operating sensors allow TIC Manufacturers to mix brands of sensors in their product line – sometimes using a mix of sensors in the same TIC housing, providing greater selection for the end-user.
- In addition to the sensor testing done by the TIC Manufacturer, further applications testing is conducted by the FS/FR TIC end-user during performance evaluations (live burns, drops, dunks, etc.). This is to ensure that the sensor will survive the rigors of FS/FR applications and deliver the image quality and sensitivity over the range of temperatures that the end-user expects.

2. What performance testing is done and how can it improve?

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Total Package Performance Testing

- The FS/FR market is very Total Package performance testing oriented. There is not a tool or piece of equipment used by FS/FRs that is not extensively tested for safety, durability, reliability and ease of use. This is "fit for use" testing that is taken to the extreme.
- Since 1896, the National Fire Protection Association (NFPA) has established safety codes and standards for FS/FRs worldwide. Even though there currently are no NFPA published standards for FS/FR TICs, existing NFPA standards for other FS/FR tools and equipment are setting the benchmark for TICs (examples: drop/impact, vibration, water/dust ingress, direct flame/heat exposure). As the NFPA moves toward establishing TIC standards, TIC Manufacturers anticipate those standards, and are developing TICs to meet them.

2. What performance testing is done and how can it improve?

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How can Performance Testing improve?

- Sensor performance testing, above and beyond specification conformance and "fit for use" testing, generally does not exist. Three is no doubt that there will be NFPA sensor performance standards set for TICs in the future. These could include:
  - viewing range
  - field of view
  - sensitivity
  - scene dynamic range
  - sensor operating temperature.
- These metrics currently exist and once a NFPA standard is established, will be easily conformed to.

2. What performance testing is done and how can it improve?

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- Total package performance testing will be improved once NFPA standards are established for TICs. Third party testing is currently in place for NFPA certification of existing tools and equipment for which NFPA standards have been established.
- Additional standards/performance testing will have to take into account the balance between the additional needs and wants of the FS/FR end-user – and the limits of sensor applications and cost.
- TIC Manufacturers will always attempt the meet the needs of the FS/FR market. Unlike other FS/FR tools and equipment though, TICs are not under the complete control of the TIC Manufacturer. Sensor performance testing on sensor attributes not controlled by the TIC Manufacturer will be an issue.

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3. What technological advances are on the horizon?

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- Once FS/FR TICs become NFPA standards driven, the ongoing revisions of the standards will have an impact on how the FS/FR TIC advances technologically in the years to come.
- Outside of technological advances driven by the NFPA standard, Sensor Manufacturers who choose to stay in the FS/FR market will take more of the FS/FR requirements into account when designing and developing new sensors.
- In addition, sensor costs will continue to decline, making TICs more available and accessible to the larger FS/FR market.

4. What performance standards are most important?

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- Outside of the Sensor and Total Package performance standards mentioned previously, there is the area of Operational performance standards that is most important in a newly developing market.
- Operational performance standards will establish a common language and understanding in the FS/FR TIC market that generally does not exist at this time. With FS/FR TIC market penetration at only 25%, the opportunity exists to establish operational performance standards that can create a universal understanding of how FS/FR TICs operate, especially with regards to safety.
- (A similar operational performance standard would be the FS/FR SCBA low air warning that alarms at 25% breathing air remaining. When the alarm sounds, every firefighter understands what it means – and what to do).

4. What performance standards are most important?

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- An example of the confusion that exists due to a lack of operational performance standards for FS/FR TICs is the different settings and ranges established by the Manufacturers that could confuse FS/FR end-users when they switch from one TIC to another.

Table 4: ***Random Sampling of TIC Operational Settings and Ranges from TIC Manufacturers' Published Information and Specifications***

Red Pixels At:	Low Battery Indicator	Dynamic Range	Heat Test
500°F	Red LED – 15 min	Nominal 315°C	300°F – 15 min
1000°F	Flashing Red LED – 1 min	932°F Nominal	500°F – 5 min
887°F	'Low Bat' icon – 20% left	1100°F	80°C – 30 min
900°F	Battery Gauge icon	1,024 Temp Levels	500°F – 8 min

4. What performance standards are most important?

NIST Workshop on Thermal Imaging Research Needs

- In addition, there are several different terms used by TIC Manufacturers, that generally mean the same thing.

Table 5: ***Random Sampling of TIC Operational Terms from the TIC Manufacturers' Published Information and Specifications***

Sensitivity	Color Pixels	Temp Sensing
Nominal Sensitivity	Color Enhancement	Relative Heat Indicator
Variable Sensitivity	Heat Seeker	On-Screen Temp Readout
Temperature Sensitivity	Red Hot	Direct Temp Measurement
NETD	Red-Colorization	Relative Temperature Bar

4. What performance standards are most important?

NIST Workshop on Thermal Imaging Research Needs

- Also, TIC Manufacturers often have several different TICs in their product line, often with different settings and ranges due to the use of different sensors.
- This can create confusion when a Fire Department adds additional new TICs to its existing inventory of older TICs from the same TIC Manufacturer.
- Examples of the confusion between the two different models of TIC could be different warning signs (low battery, high heat) – and different setting for temperature measurement and red pixel activation.
- Even with training, usage is open to confusion when multiple models of TICs used, especially when TIC usage is sporadic.

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5. What are the most critical issues in establishing performance standards?

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- Currently, the TIC and Sensor Manufacturers are meeting the growing needs of the FS/FR market. The evidence is seen in the market growth in the past several years.
- The FS/FR market has placed demands on the TIC Manufacturers – and to date all have been met. Examples are the elimination of "white out" in 1997, adding temperature measurement beginning in 1998, reducing size and weight beginning in 2001, the ongoing improvement of image quality and reduction in cost while adding value.
- The FS/FR market and the NFPA, working together with the TIC and Sensor Manufacturers can continue to meet real needs in practical ways through mutual understanding and cooperation.

5. What are the most critical issues in establishing performance standards?

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- NFPA will help in establishing Operational and Total Package and Sensor performance standards. The most critical issues in establishing Sensor performance standards is whether FS/FR TIC needs and budgets match up with the capabilities of the IR sensors.
- If a performance standard is established that requires a sensor for specific types of fires – or specific FS/FR applications, the standard could segment the market, requiring both TIC and Sensor Manufacturers to develop a new FS/FR TIC that might not be viable (due to low volume and high cost). Then, no one benefits.
- Also, if a performance standard is established that requires a FS/FR applications specific sensor, once it is developed the industry could be reluctant to advance TIC technology beyond that sensor, realizing the initial investment/long payback period due to market segment size.