INFRARED TECHNOLOGY & APPLICATIONS
COURSE CONTENT* SUMMARY

FIRST DAY

Applications and state-of-the-art systems are discussed beginning with basic infrared theory but transitioning quickly into immediate application issues to provide a real-world framework for the theory.

Basic Concepts

- Why do solid bodies exhibit continuum spectra while gases show so-called "line" spectra?
- What is radiation contrast?
- What are graybodies and selective radiators?
- How does the mid wave compare to the long wave band in contrast? Sensitivity? Atmospheric propagation?
- What is meant by a "pedestal"?
- What effect does a pedestal have on IR system design?
- How do fog, rain, and smoke impact IR systems?

Basic radiometric relationships are defined and explained.

IR Imaging Systems

- What is a "FLIR" and how do developed FLIRs work?
- What is meant by Serial vs. Parallel scanning?
- What are the limitations of present scanning FLIRs?
- What is Time Delay and Integration (TDI)?
- How will Focal Plane Arrays (FPAs) improve imaging systems?
- How are Second Generation FLIRs being configured?
- How well do present FPAs perform?
- What features will Third Generation FLIRs have?
- What key peripherals work with FLIRs?

Example state-of-the-art FPA video imagery is demonstrated.

SECOND DAY

The second day continues the IR Imaging Systems lecture for most of the morning. The rest of the day then begins a process of backfilling basic infrared theory, extending it to scene and target signature mechanisms, and then continues with more applications and state-of-the-art system discussions of Terminal Homing Seekers and Infrared Search & Track systems.

Properties of Scenes and Targets

- How does background clutter impact system performance?
- How do we quantify background clutter?
- What do infrared clutter distributions look like?
- What physical mechanisms drive target infrared signatures?
- What physical processes are involved in the heat propagation through target structures? Soils? Foliage?
- How does hyperspectral imaging separate man-made objects from natural background clutter?

Example time-lapse imagery is shown to illustrate the subtle changes produced by the diurnal cycle and associated microclimates.

Terminal Homing Seekers

- What guidance laws do IR seekers typically use?
- What are the differences between "imaging" and "non-imaging" seekers?

*content is representative in that the course is under constant revision to incorporate continuing developments in the field

- How do center-spun and conical scan reticle seekers track targets?
- What is the difference between AM and FM seeker track processing?
- Why are imaging seekers emerging?
- What role have countermeasures played in seeker development?
- What are the advantages of laser beam-rider missiles?
- How do pseudo-imaging seekers work?
- What are the trends in IR seeker design?
- How do Infrared Search & Track (IRST) systems work?
- What major new capabilities do newly emerging IRSTs have?

Videotapes are used to help illustrate IR missile and IRST operating principles

THIRD DAY

The third day continues the IR seeker and IRST system application lectures but then transitions to key infrared enabling technologies including video trackers, optics & displays, and detectors.

Video Trackers

- How do Video Trackers work?
- What is an Adaptive Gate Centroid Tracker? MTI? Area Correlation? Multi-mode? Feature?
- What limits tracker performance?
- What determines maximum track rate?

Video tracker problem areas are explained and discussed.

IR Optical Design

- What does the systems engineer have to know to communicate with the optical design specialist?
- What are some of the key differences between visible optics and infrared optics?
- What overall optical configurations often appear in IR system designs? What compromises are made?
- What parameters determine field of view? Resolution?
- How are windows designed to minimize signature and drag while preserving resolution?
- What are recent developments in optics, and what impact are they having?
- What optical techniques are essential to video displays such as HUDs, HMDs, and HDDs?
- What new and potentially disruptive breakthrough technologies are on the horizon?

Motivations pushing recent trends in optical window, lens, and display design and fabrication are explained.

Detectors

- What materials are suitable for IR detection?
- What detection mechanisms work to capture IR radiation?
- What determines the choice of detector type for a given application?
- Why do some detectors have to be cooled?
- What merit functions characterize IR detectors?
- What material problems are being addressed to produce large area arrays?
- What role will quantum wells play in advanced detectors? Superconductors?
- What are the issues facing FPA cost and yield?

The rationale favoring some arrays for certain applications is discussed.

FOURTH (1/2) DAY

The last day ends by noon and is devoted exclusively to system design, specification, and evaluation. The latter discussion ties together all previous material by showing how system designs evolve by "flowing down" top -level mission requirements into detailed component specifications.

Evaluation Tools

- How is system resolution modeled?
- How does classical linear systems theory apply to infrared systems?

- What is a modulation transfer function?
- How does one predict the signal amplitude seen by an infrared system?

An example problem is analyzed to show how IR missile lock-on probability depends on resolution maintained during launch.

System Performance Analysis

- What is meant by “target acquisition”?
- What is the significance of “bar target equivalency”?
- What resolution is needed for target acquisition?
- What is Minimal Resolvable Temperature or MRT and the new Contrast Threshold Function or CTF?
- How does MRT or CTF allow acquisition range prediction?
- How does MRT or CTF allow specification of subsystem design parameters?
- What are the steps in the design specific?
- How do we know an IR system will meet its performance requirements?

IR system performance sensitivities, historical evaluation problems, and accuracy achievements are assessed.

In summary, while this course is described as an “Introductory” course that label is only applied because no a priori knowledge about infrared systems is assumed – only that the attendees have an undergraduate degree in engineering, science, or mathematics. However, this course prides itself in going well beyond the basics to cover the key technologies and associated issues being debated in the infrared community today. ***Our goal is to explain them well enough so the student can sit in on meetings with senior staff in their home organizations and not only understand the discussions but be confident enough in their knowledge to contribute to them as well.***