MIT
Security Studies Program

A Summary of Technical Findings that Result from the Cooling System Failure in the IFT-1A National Missile Defense Experiment

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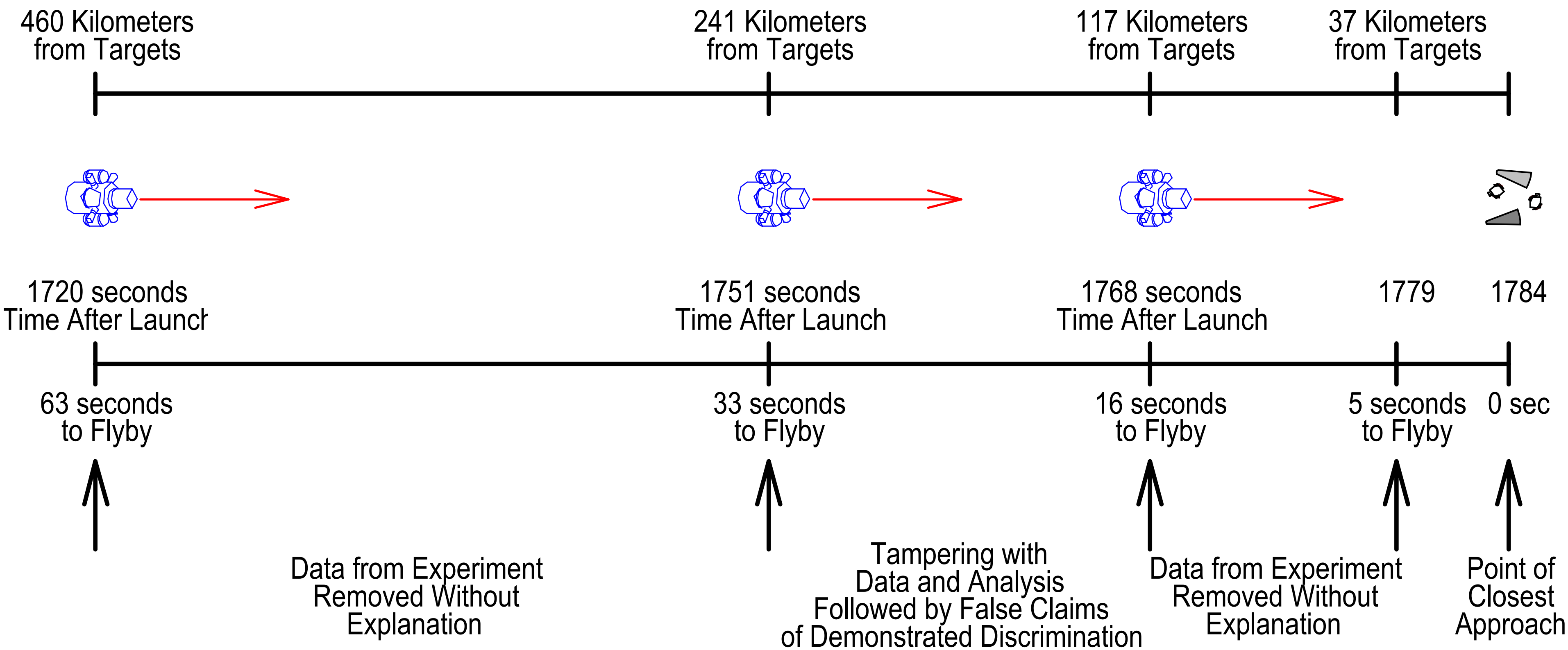
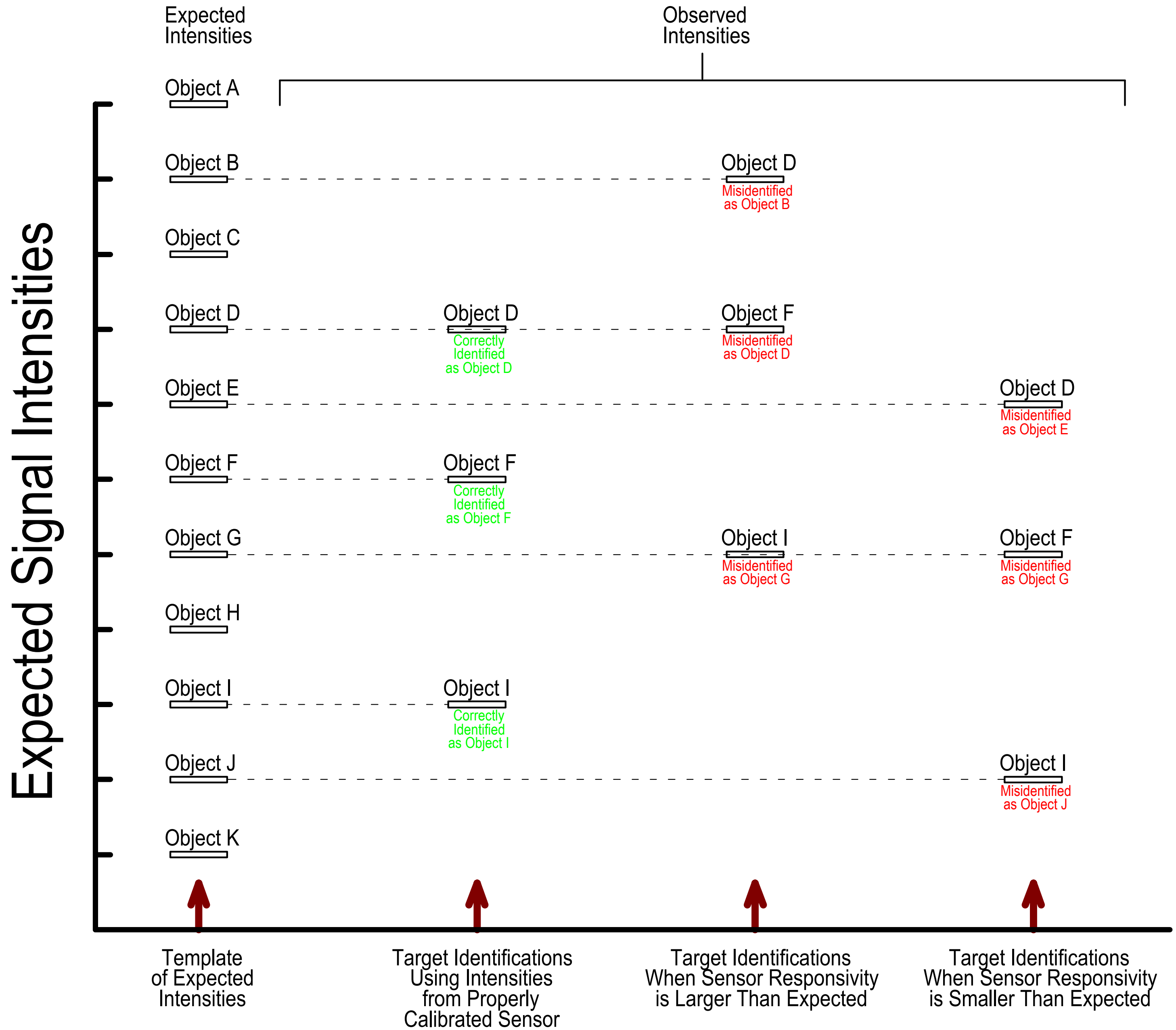
Timelines and Ranges Relevant to the IFT-1A Experiment and Its Reported Analysis

Timeline of Experiment and Tampering With Data and Algorithms



Why Accurate Sensor Calibration is Critical to the Target Identification Process

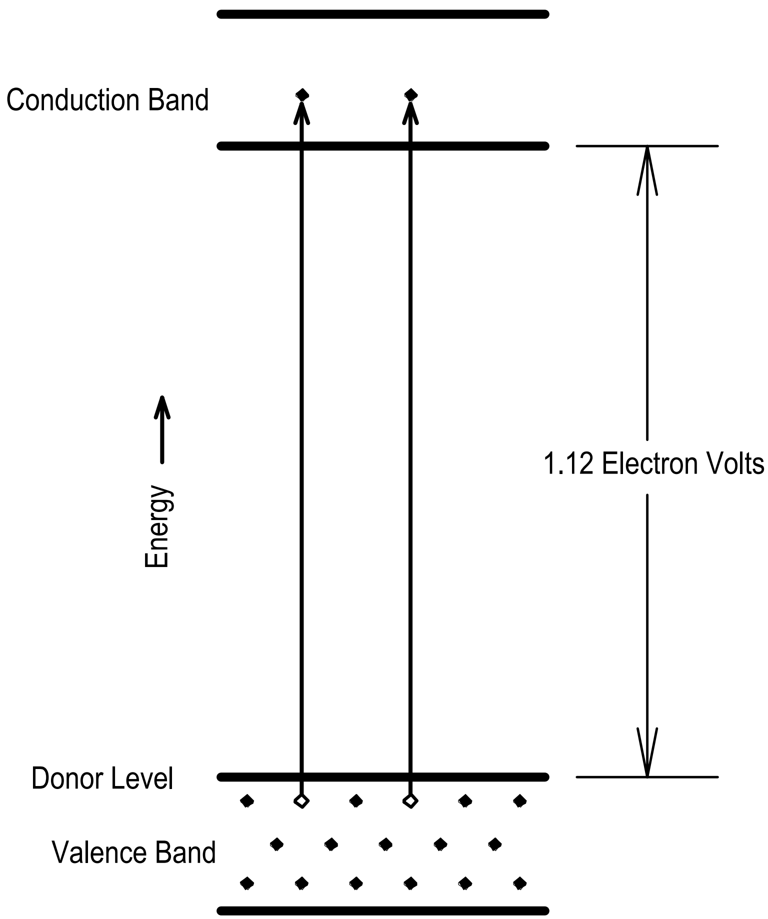
Why Targets Will Be Incorrectly Identified if Sensor Is Not Properly Calibrated



Why the Thermal Noise Levels in the Silicon Arsenide Detector Change Very Strongly with Temperature

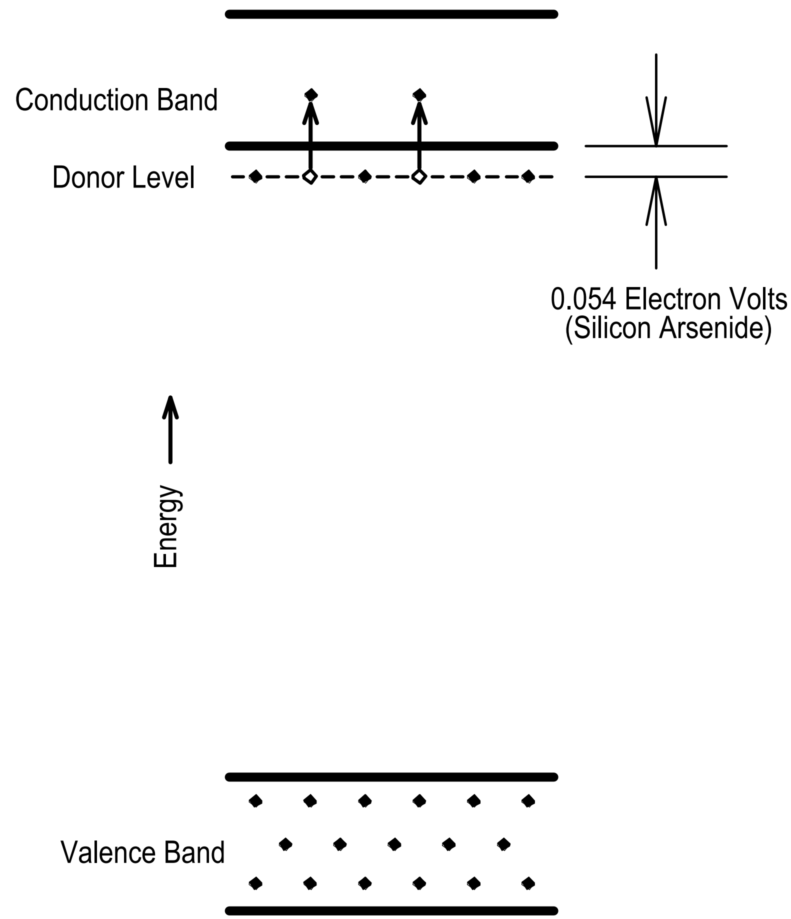
Energy Band Characteristics of Silicon and Silicon-Arsenide Photo-Detector Materials

Energy Band Structure of Pure Silicon



Intrinsic Semiconductor

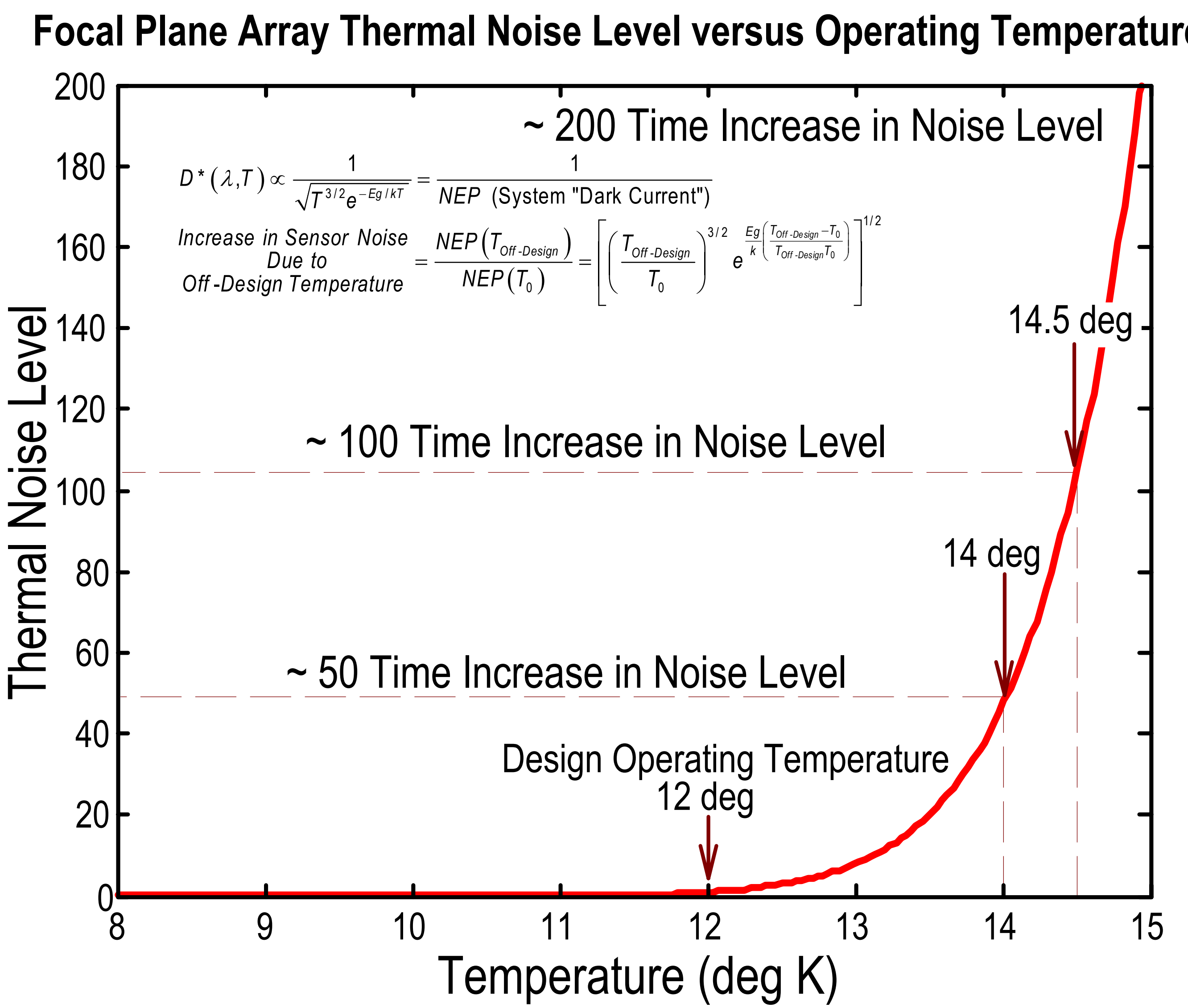
Energy Band Structure of Silicon Doped with Arsenic



Arsenic Doped
Extrinsic n-Type Semiconductor

$$300^\circ K \times \frac{.054}{1.12} = 14.5^\circ K$$

Rough Estimate of Change in Thermal Carrier Generation-Recombination Noise as a Function of Temperature for a Silicon Arsenide Detector Designed to Operate at 12 °K



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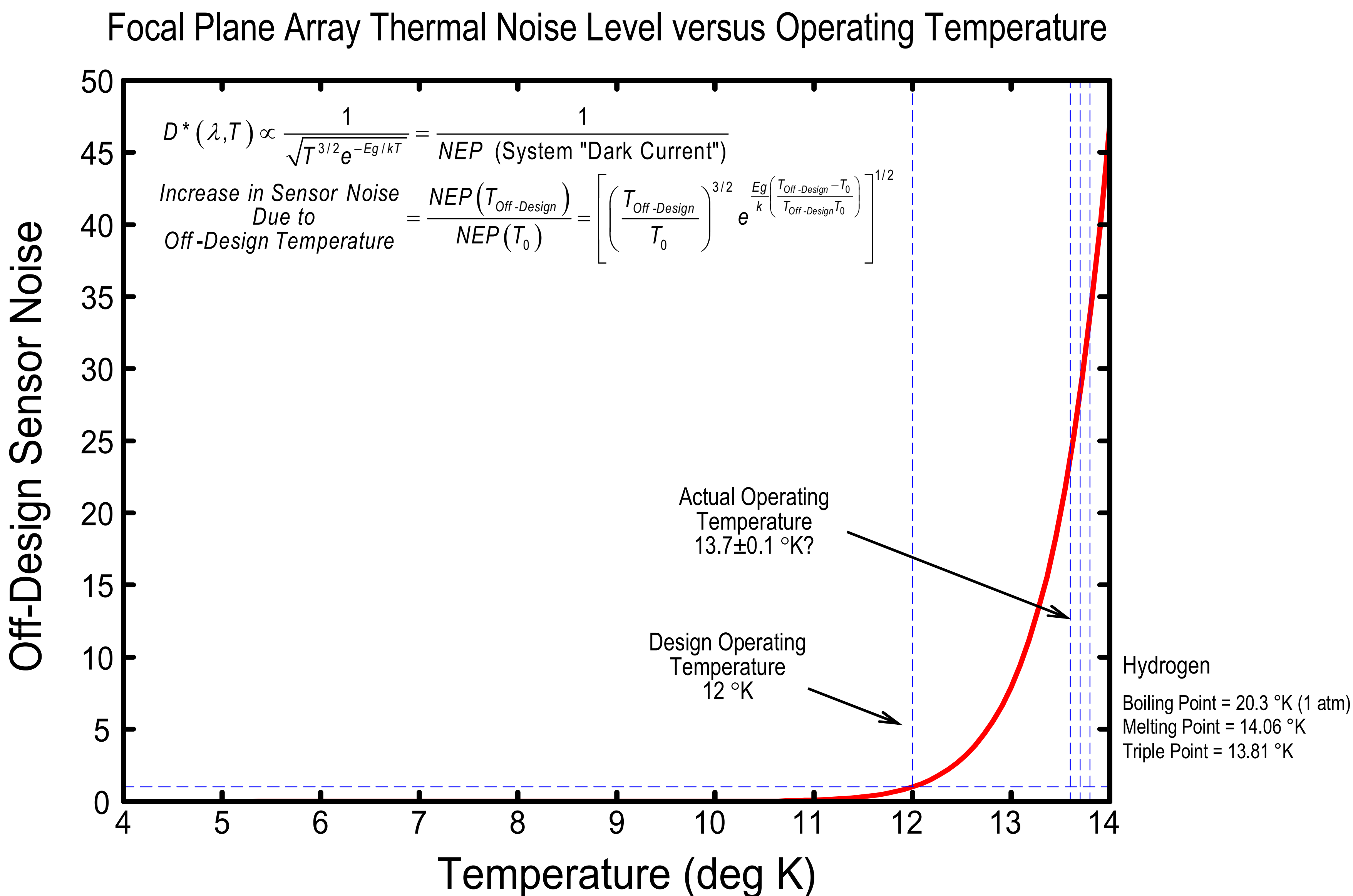
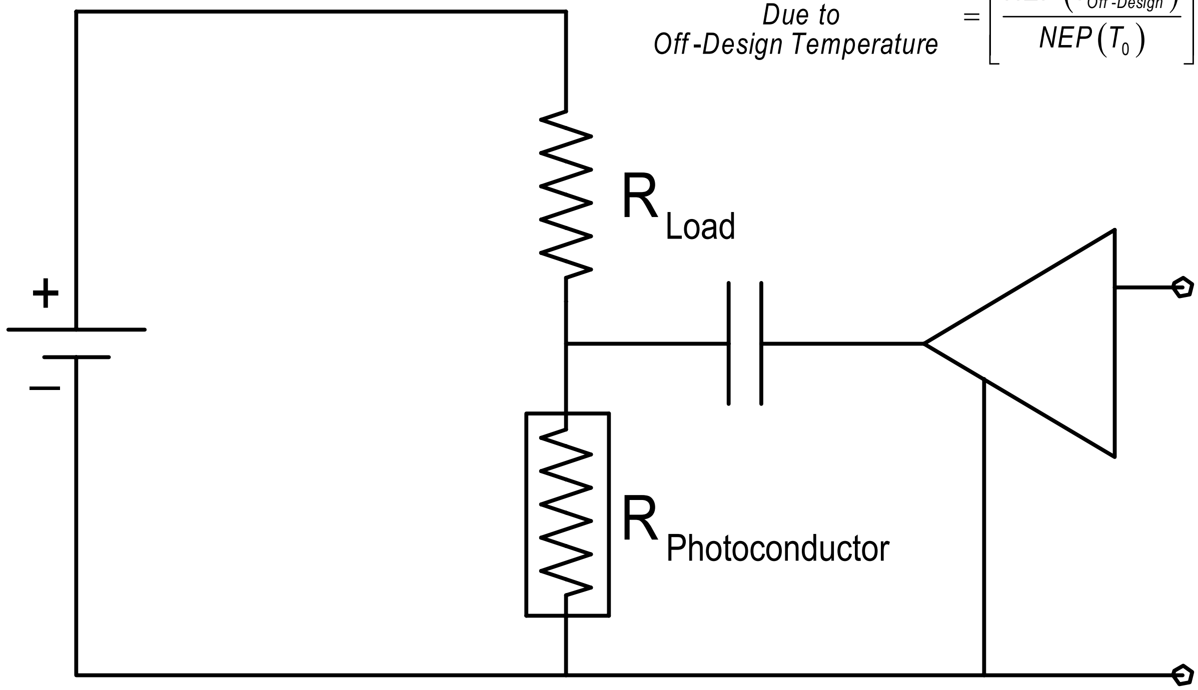


Why the Calibration Characteristics in the Silicon Arsenide Detector Change Very Strongly with Temperature

Detectivity and Responsivity Changes with Temperature

$$\begin{matrix}\text{Increase in Sensor Current}\\ \text{Due to}\\ \text{Off-Design Temperature}\end{matrix} = \left[\frac{NEP\left(T_{Off\text{-}Design}\right)}{NEP\left(T_0\right)}\right]^2 = \left(\frac{T_{Off\text{-}Design}}{T_0}\right)^{3/2} e^{\frac{Eg}{k}\left(\frac{T_{Off\text{-}Design}-T_0}{T_{Off\text{-}Design}T_0}\right)}$$



$$i_0 = \frac{V_{PowerSupply}}{R_{Load} + R_{Photoconductor}} \qquad i_0 = \frac{V_{OutPutSignal}}{R_{Photoconductor}}$$

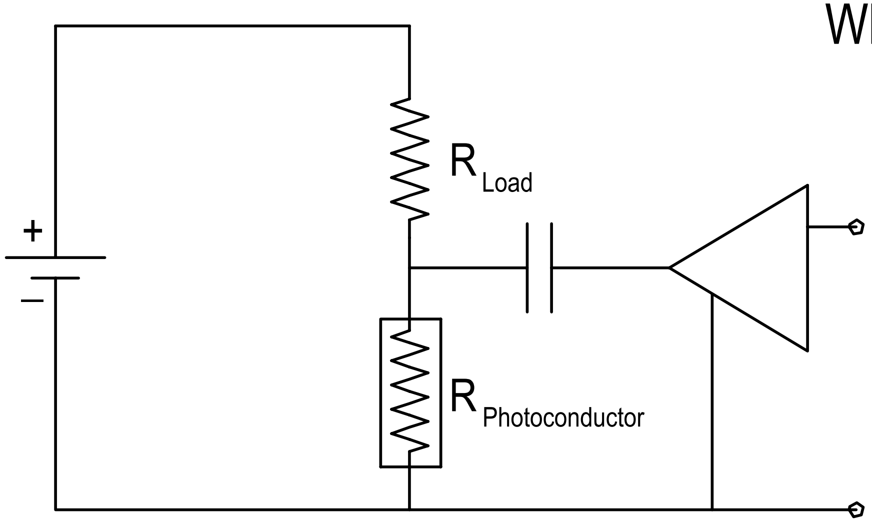
$$\frac{V_{OutPutSignal}}{R_{Photoconductor}} = \frac{V_{PowerSupply}}{R_{Load} + R_{Photoconductor}} \qquad V_{OutPutSignal} = \frac{V_{PowerSupply} R_{Photoconductor}}{R_{Load} + R_{Photoconductor}}$$

$$\delta V_{OutPutSignal} = \left(\frac{1}{R_{Load} + R_{Photoconductor}} - \frac{R_{Photoconductor}}{\left(R_{Load} + R_{Photoconductor}\right)^2}\right) V_{PowerSupply} \, \delta R_{Photoconductor}$$

Detectivity and Responsivity Changes with Temperature

Detectivity as a function of temperature for conditions where the thermal carrier generation recombination noise is much less than the photo-generation noise is

$$D^*(\lambda,T)=\frac{\dfrac{\eta\lambda}{2hc}}{\left[\eta E_{q,\mathrm{bkg}}+\dfrac{2\ell_x\aleph_r}{\delta_d}\left|\mathrm{n}_d-\mathrm{n}_a\right|\left(\dfrac{2\pi m^*kT}{h^2}\right)^{3/2}e^{-E_g/kT}\right]^{1/2}}$$



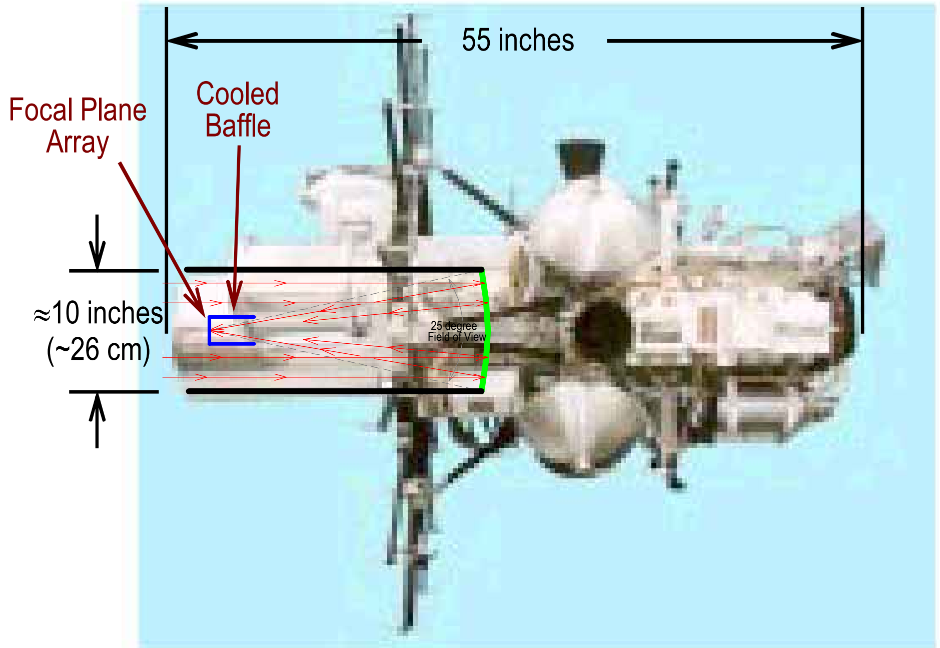
Where

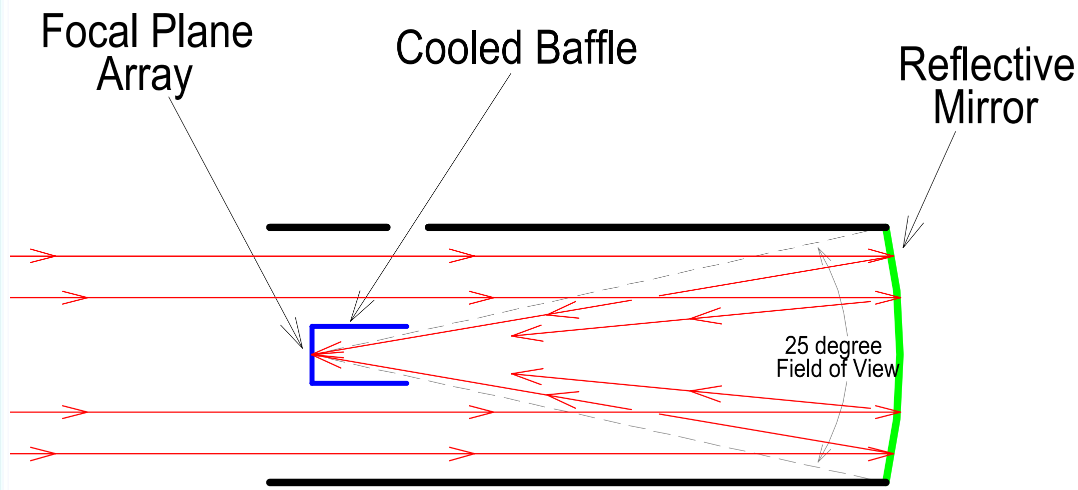
- $D^* \equiv$ Detectivity
- $E_{q,\mathrm{bkg}} \equiv$ Background photon field noise
- $\eta \equiv$ Quantum Efficiency
- $\ell_x \equiv$ Crystal Thickness
- $m^* \equiv$ Effective Mass of Majority Carrier
- $E_g \equiv$ Band Gap $\approx$ .054 eV
- $\aleph_r \equiv$ Recombination Coefficient
- $\delta_d \equiv$ Degeneracy Factor (2 for donors in Silicon)
- $\mathrm{n}_d \equiv$ Donor Impurity Concentration
- $\mathrm{n}_a \equiv$ Acceptor Impurity Concentration

How the Sensor in the IFT-1A Should Have Performed at Its Design Temperature

(Estimate of Detectivity of the Silicon Arsenide Detector and Optics Used in the IFT-1A Experiment)

Estimated Characteristics of Boeing Kill Vehicle Optics

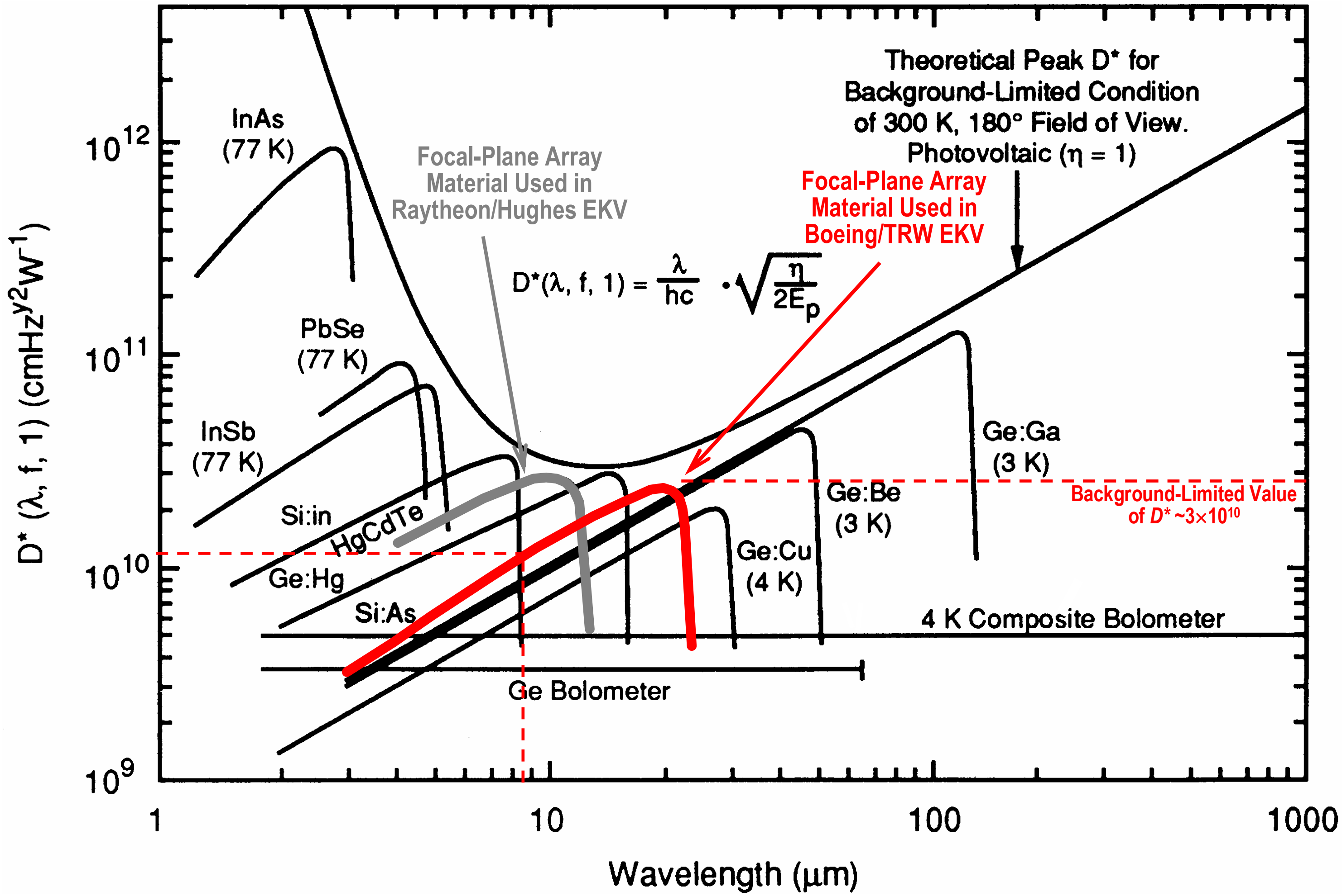




$$\textit{Fraction of } \pi \textit{ Steradians Exposed to Hot Mirror} = \frac{\delta A_{Mirror}}{\pi R^2} = \frac{\pi\left(R\sin(\theta/2)\right)^2}{\pi R^2} = \sin^2(\theta/2) \cong .04$$

$$\textit{Reduction in Photon Noise} = \frac{1}{\sqrt{\frac{\delta A_{Mirror}}{\pi R^2}}} = \frac{1}{\sin(\theta/2)} \cong 5$$

Estimated Detectivity of the Boeing Silicon-Arsenide Focal Plane Array



NOTES:

Since the EKV SiAs sensor is exposed to the uncooled mirror of the EKV telescope, it is also operating in a 300 °K background-limited thermal radiation field. However, the reflectivitiy of the mirror should be very high ($\rho \sim 0.99$), and consequently the optics emissivity (ε=1-ρ) should be very low (ε~0.01). As shown in the diagram of the optics, there should be an additional reduction in the background flux of 20, due to the use of a cooled baffle to limit the sensor field of view to the mirror. The background limited noise is proportional to the square root of the intensity of the radiation field. It is about two thousand times less intense than that of a 300 °K black body. Since the sensor is being operated as a *Photoconductor*, not a *Photovoltaic*, there is an additional reduction factor of 2 in the background limited noise contribution to the detectivity from recombination noise. As a result, the actual intensity of the radiation field is about one thousand times less intense than that of a 300 °K black body. This means that the values for the detectivity of the Kill Vehicle sensors should be about 30 times larger than those shown in the figure to the left. The estimated Detectivity needed to achieve a signal-to-noise of one when sighting on the Alpha Boo star in the 6.8 to 10.8 μm band with a one tenth of a second integration time is about 3.7×10^{10}. From the left figure, it can be seen that the expected achievable detectivity of the EKV sensor in that band should be about 30 times 3×10^{10}, or about 1×10^{12} cm $Hz^{1/2}$/w. This estimate assumes that the sensor-optics system has been properly designed. Proper design dictates that the thermal generation-recombination noise at the 12 °K sensor operating temperature will be roughly equal to the background photon noise from the uncooled optics.

Estimated Detectivity of the Boeing Silicon-Arsenide Focal Plane Array

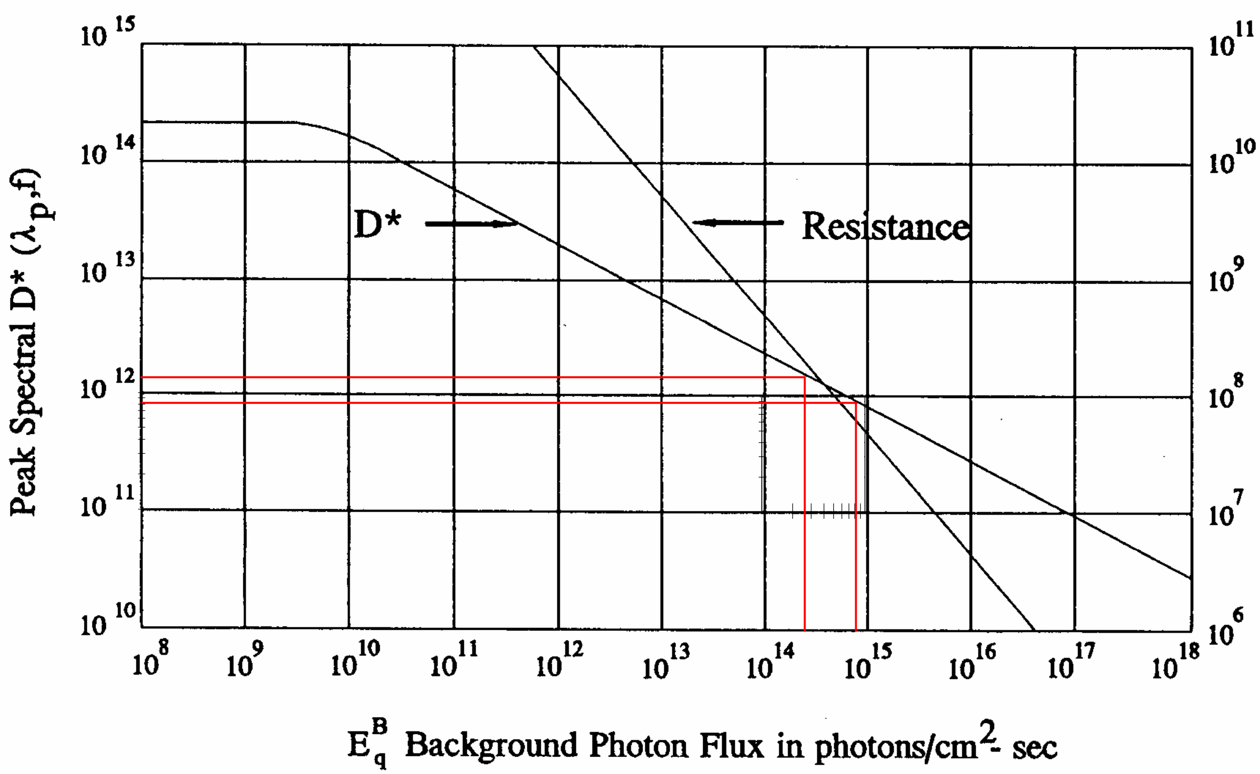


Figure 8.19. Resistance and *D** of an extrinsic silicon photoconductor as a function of background photon irradiance.

NOTES:

The left figure shows the achievable detectivity of an extrinsic silicon photoconductor as a function of the background photon irradiance. If the uncooled reflective mirror in the EKV telescope has a reflectivity of about 0.99, then the emissivity will be about 0.01. For these conditions, the in-band photon flux on the focal plane array between 6.8 and 10.8 μm will be about 5.4×10^{15} photons/cm^2/sec and between 10.8 and 22.5 μm it will be about 1.7×10^{16} photons/cm^2/sec. As shown in the diagram of the optics, a cooled baffle around the focal plane array can limit the solid angle exposed to 300 °K radiation, reducing the background by another factor of about 20. This leads to an estimate for *D** of about 1×10^{12}.

Alternatively, we note that the *D** for a background limited photoconductive sensor is given by,

$$D^* = \frac{\lambda}{2hc}\sqrt{\frac{\eta}{E_P}}$$

For the short wavelength band we get,

$$D^* = \frac{8.8\times10^{-6}}{2\times6.626\times10^{-34}3\times10^{8}}\sqrt{\frac{0.4}{\left(5.4\times10^{15}\right)/20}} = 8.5\times10^{11}$$

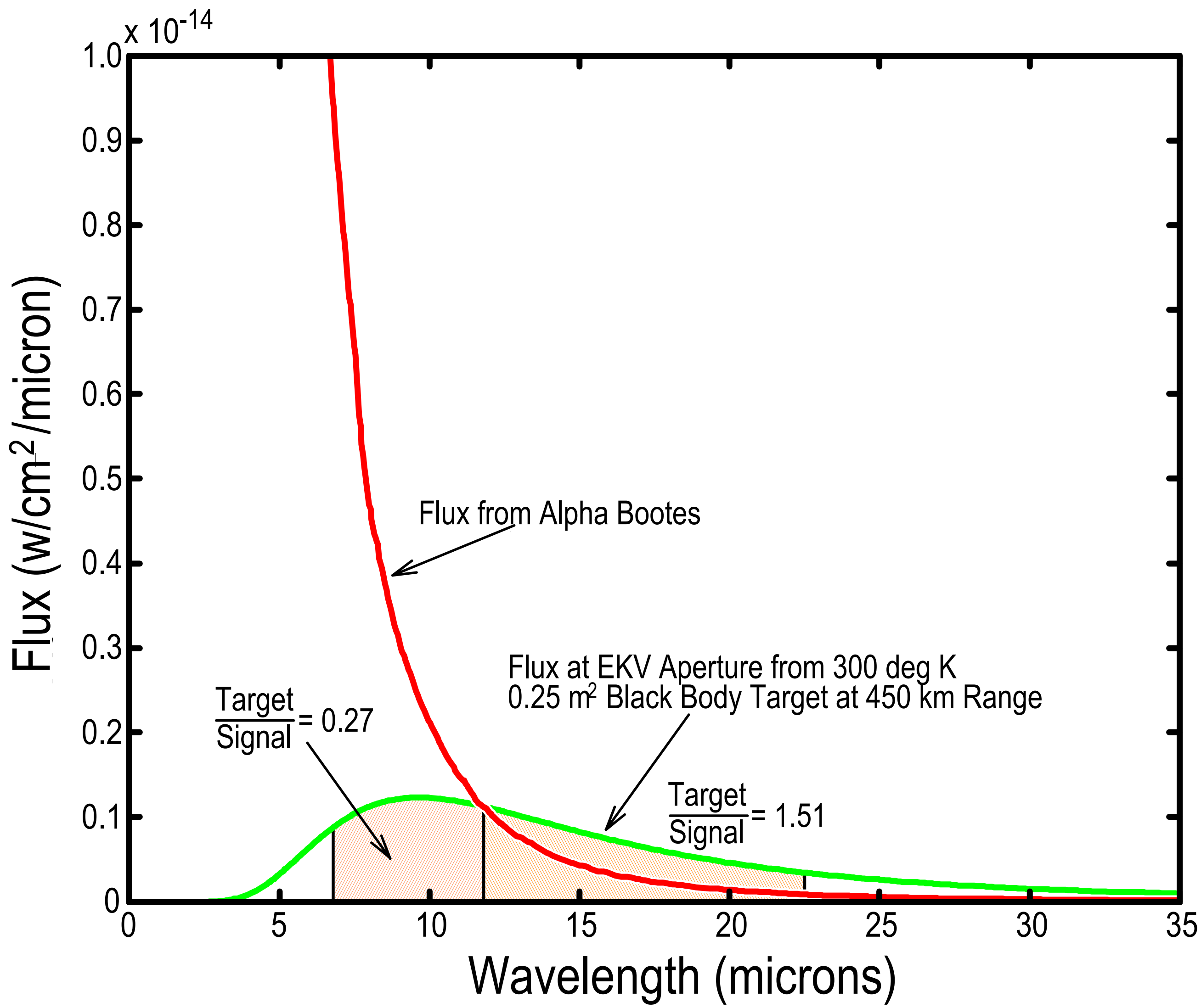
And for the long wavelength band we get,

$$D^* = \frac{16.6\times10^{-6}}{2\times6.626\times10^{-34}3\times10^{8}}\sqrt{\frac{0.4}{\left(1.7\times10^{16}\right)/20}} = 9\times10^{11}$$

Hence, all estimates of *D** lead to the conclusion that the operational detectivity should be about 1×10^{12} cm Hz$^{1/2}$/w.

Why the Sensor in the IFT-1A was Unable to Get Useful Calibration Data from Sighting on the Star Alpha Bootes

Infrared Signal Intensities for Targets Relevant to the IFT-1A Experiment



NOTES:
The above figure shows a comparison of the flux from the Alpha Boo star with the flux from a black body target at 450 kilometers range from the Kill Vehicle. The signal from the star in the 6.8 to 10.8 µm band is about three to four times larger than that from the black body target when the Kill Vehicle is at a range of 450 kilometers from the target. In the 10.8 to 22.5 µm band, the signal from the star is about two thirds of that from the black body target. It is therefore clear that if it was not possible to calibrate the sensor against the star, it was also not possible to get a good signal-to-noise measurement at the range planned for target acquisition.

Infrared Signal Intensities for Targets Relevant to the IFT-1A Experiment

Signal Intensities from Alpha Bootes and .25 m^2 300 °K Blackbody at 450 Kilometers Range

	6.8-10.8 μm	10.8-22.5 μm
Power Received from Warhead	2.45×10^{-12}watts (450 km)	4.48×10^{-12}watts (450 km)
Photons/sec from Warhead	1.08×10^{8} photons/sec (450 km)	3.75×10^{8} photons/sec (450 km)
Power Received from Alpha Boo	8.67×10^{-12}watts	2.75×10^{-12}watts
Photons/sec from Alpha Boo	3.84×10^{8} photons/sec	2.07×10^{8} photons/sec

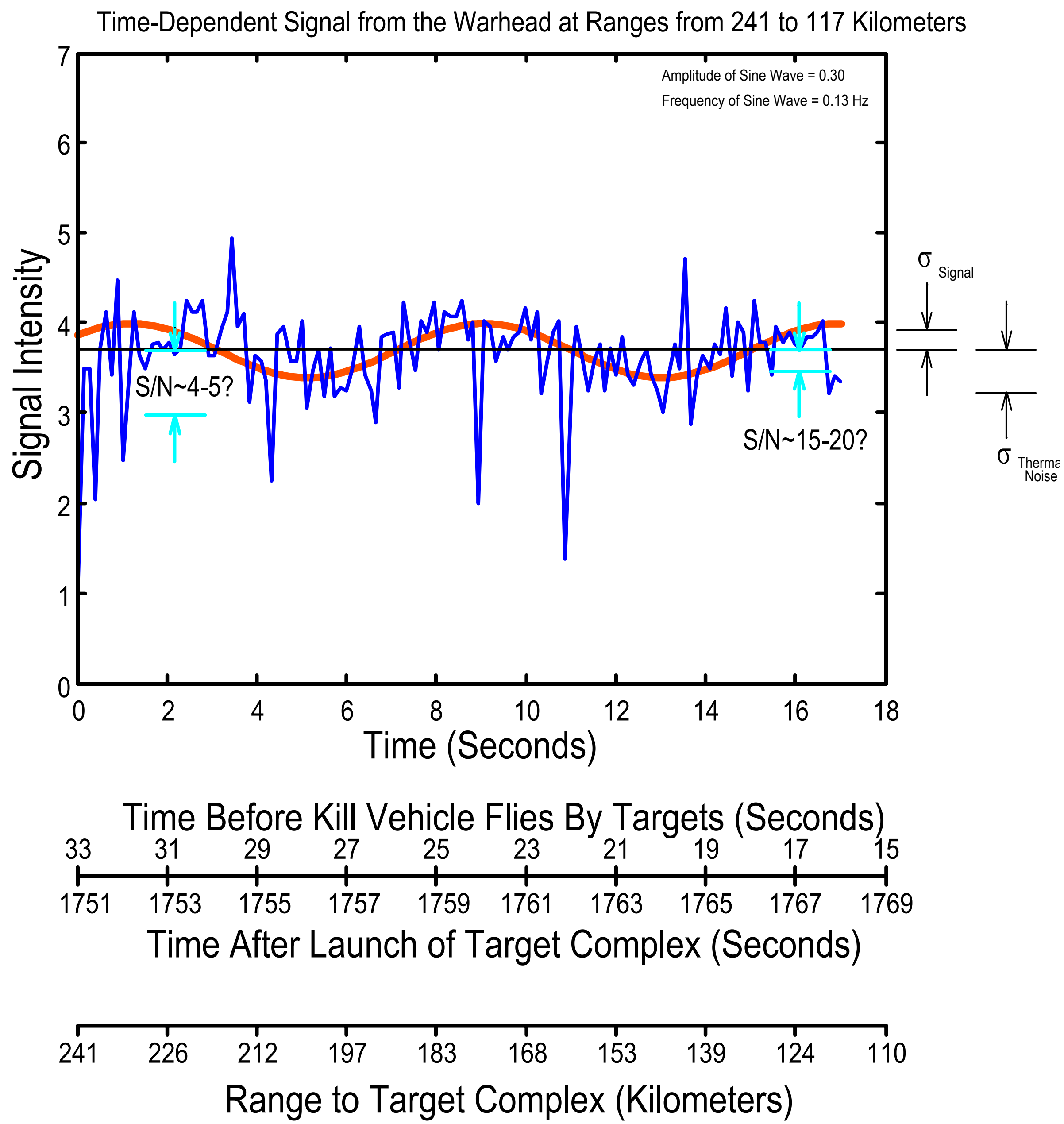
Numbers calculated using Irrad03.m and alphaboospectrum2.m

Detectivities Needed to Achieve a Signal-to-Noise of One Against Alpha Bootes

Detectivity Needed for S/N of 1 in the 6.8-10.8 μm Spectral Band	$D^* = \frac{\sqrt{A_{Detector} f}}{NEP} = \frac{0.1\,\text{cm}\sqrt{10\,\text{Hz}}}{8.67\times10^{-12}} \cong 3.6\times10^{10}\ \frac{\text{cm Hz}^{1/2}}{\text{W}}$
Detectivity Needed for S/N of 1 in the 10.8-22.5 μm Spectral Band	$D^* = \frac{\sqrt{A_{Detector} f}}{NEP} = \frac{0.1\,\text{cm}\sqrt{10\,\text{Hz}}}{2.75\times10^{-12}} \cong 1\times10^{11}\ \frac{\text{cm Hz}^{1/2}}{\text{W}}$

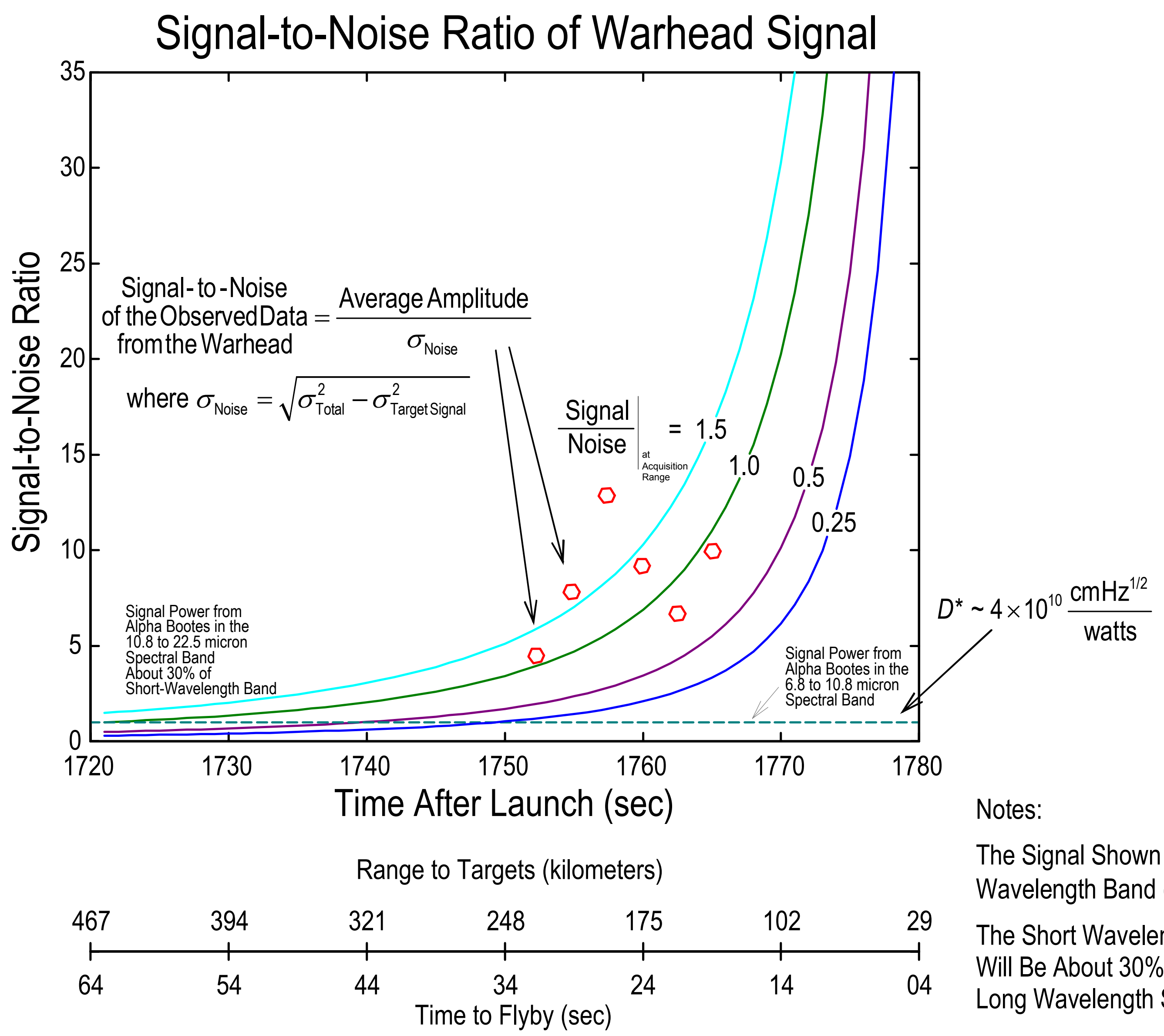
How the Noisy Signal-from the Warhead Appeared to the Sensor Between 240 and 110 Kilometers Range

Time Dependent Signal from the Warhead at Ranges from 241 to 117 Kilometers



How the Signal-to-Noise Ratio for the Warhead Changed with Range (Assuming Constant Sensor Temperature)

Range and Time-to-Go Dependence of the Infrared Signal from the Warhead

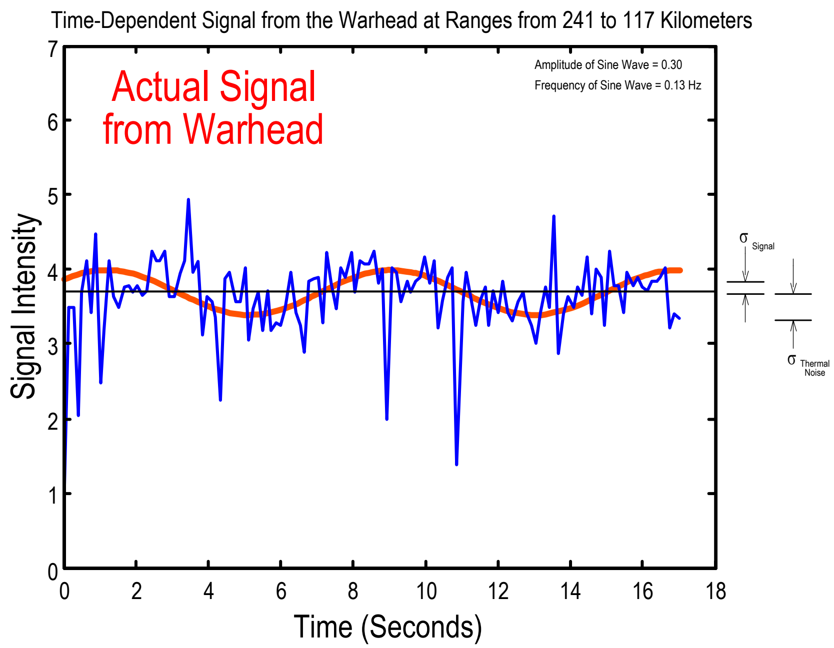


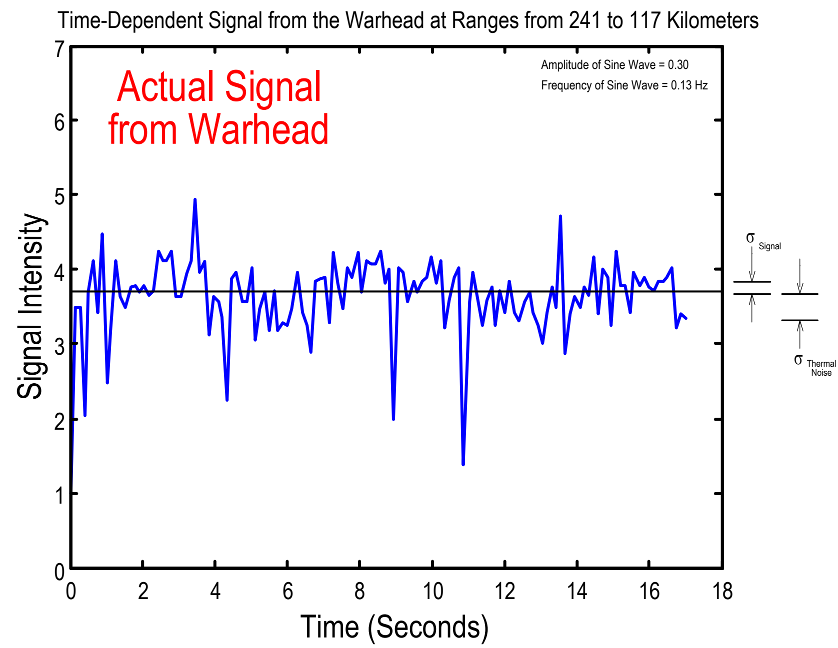
Notes:

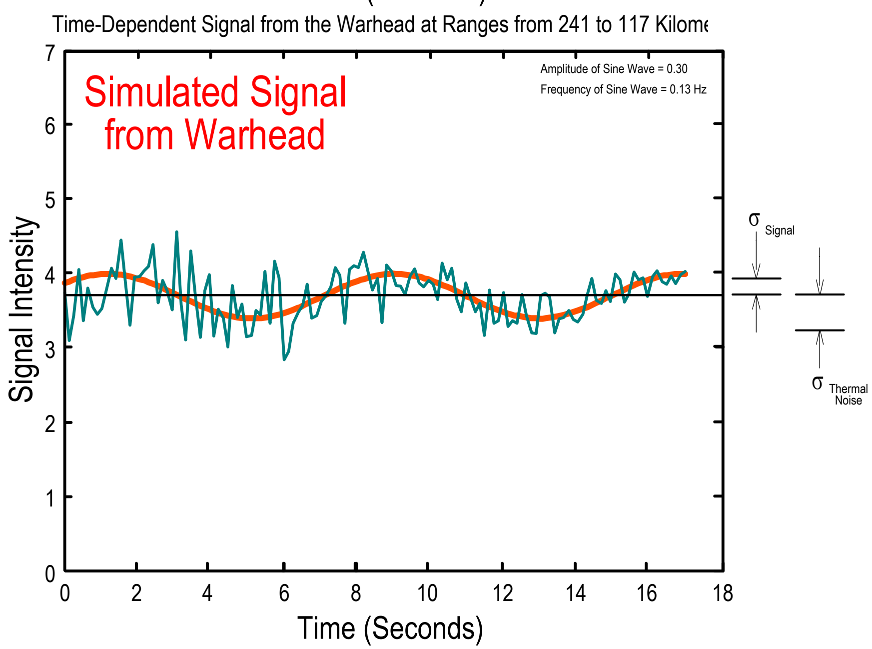
The Signal Shown is for the Long Wavelength Band (10.8 to 22.5 μm).

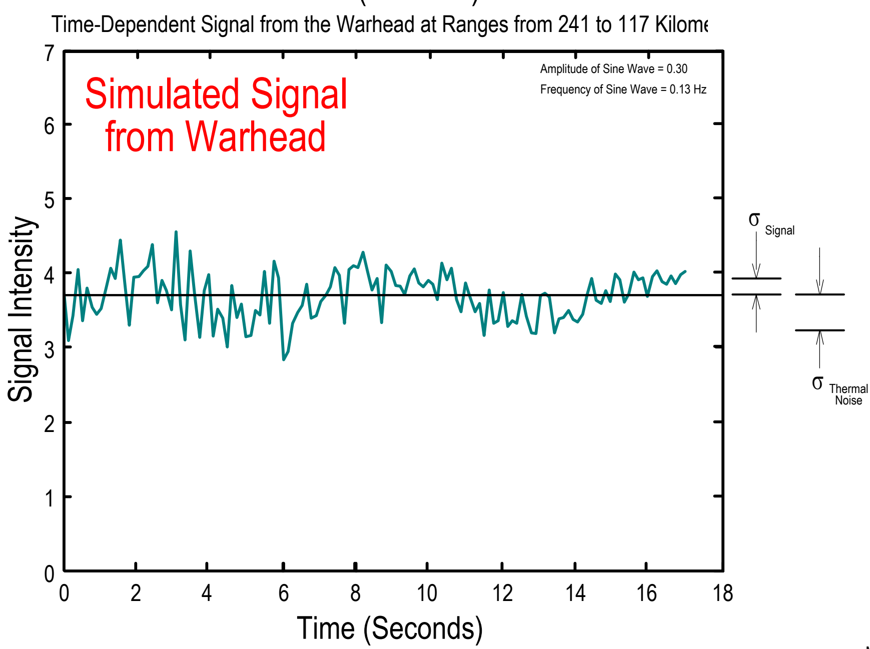
The Short Wavelength Band Signal Will Be About 30% as Large as the Long Wavelength Signal

Simulated and Actual Signal Output from Infrared Focal Plane Array



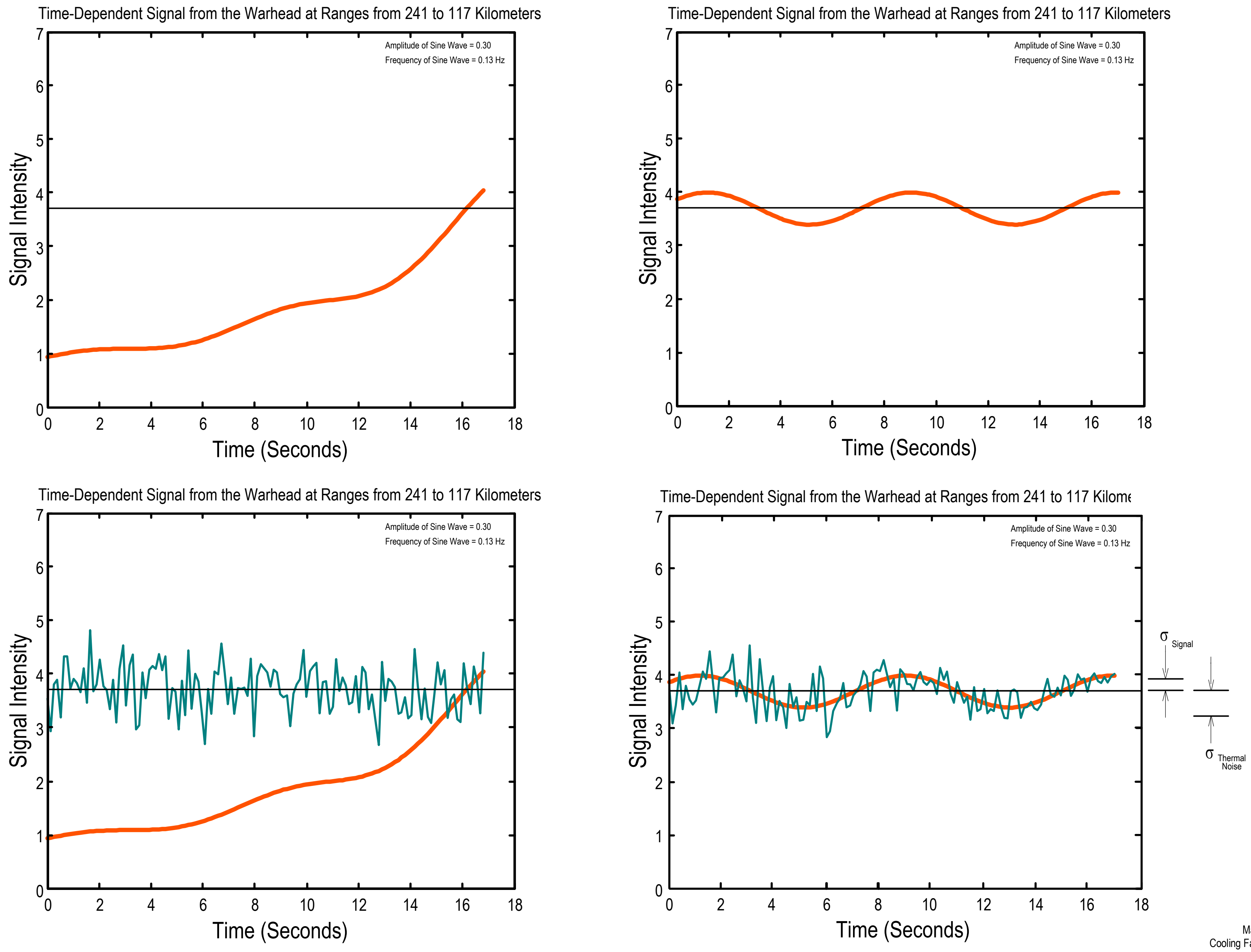




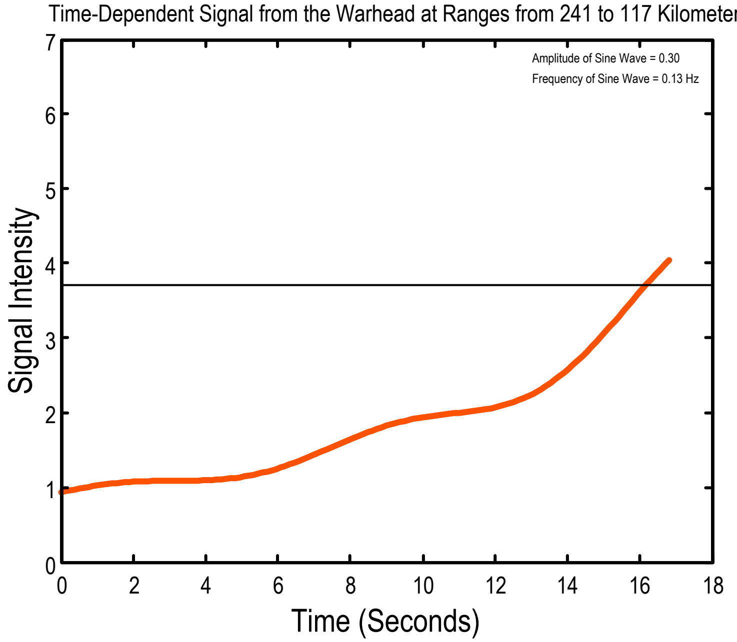


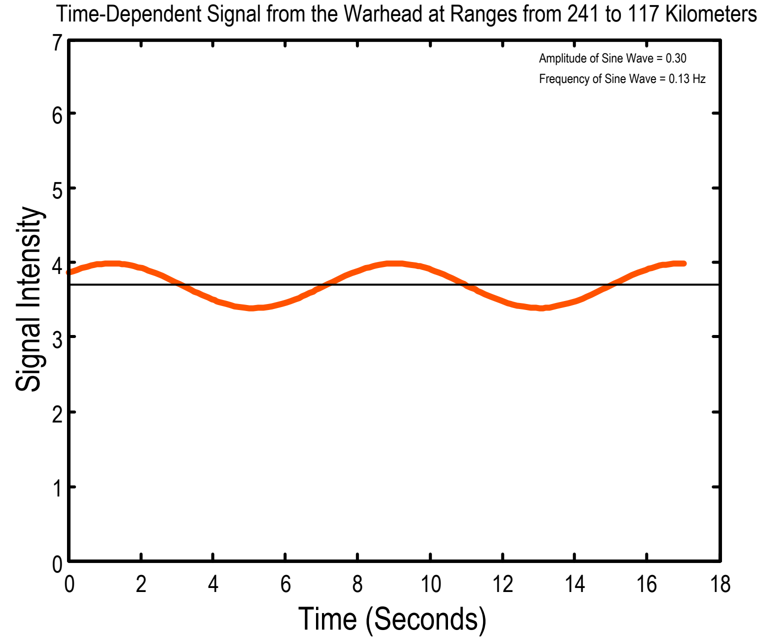
Illustrations of How the Signal from the Warhead Would Appear at the 460 Kilometer Acquisition Range (Assuming Constant Sensor Temperature)

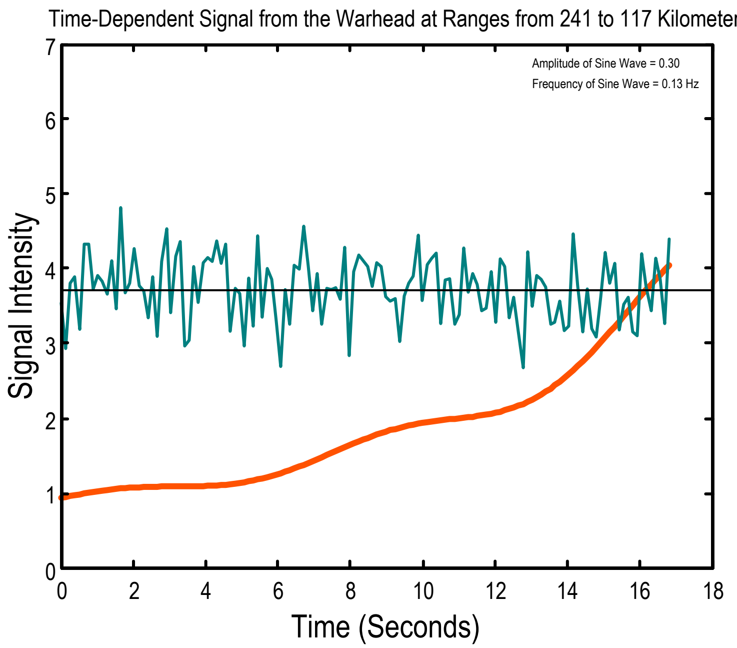
Simulated Range Dependence of Warhead Infrared Signal and Sensor Noise

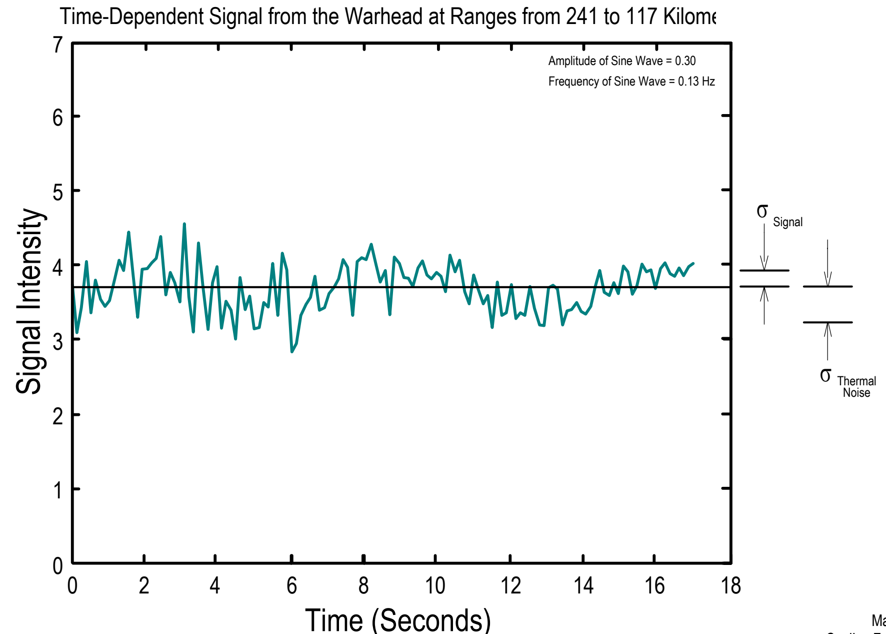


Simulated Range Dependence of Warhead Infrared Signal and Sensor Noise

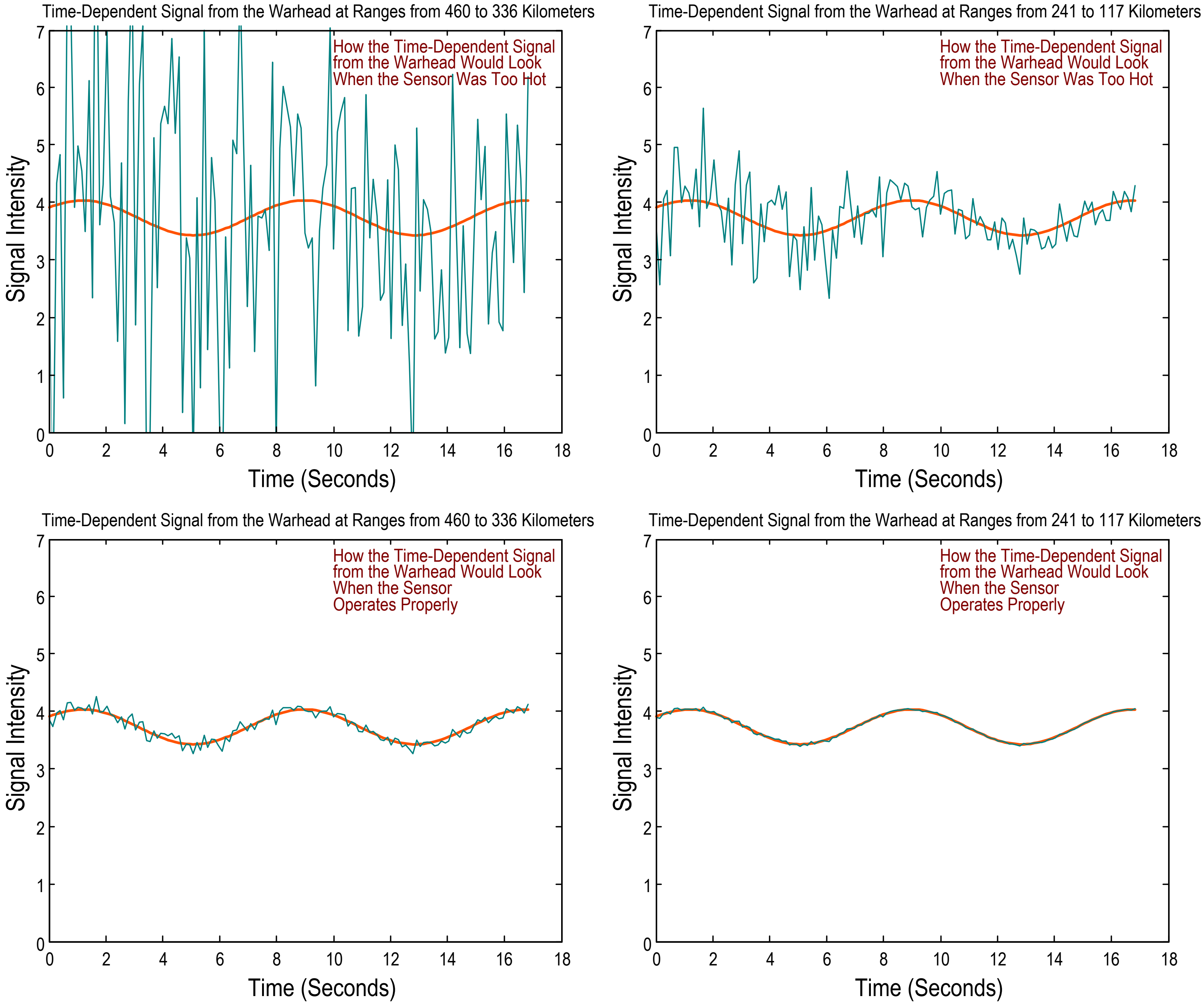




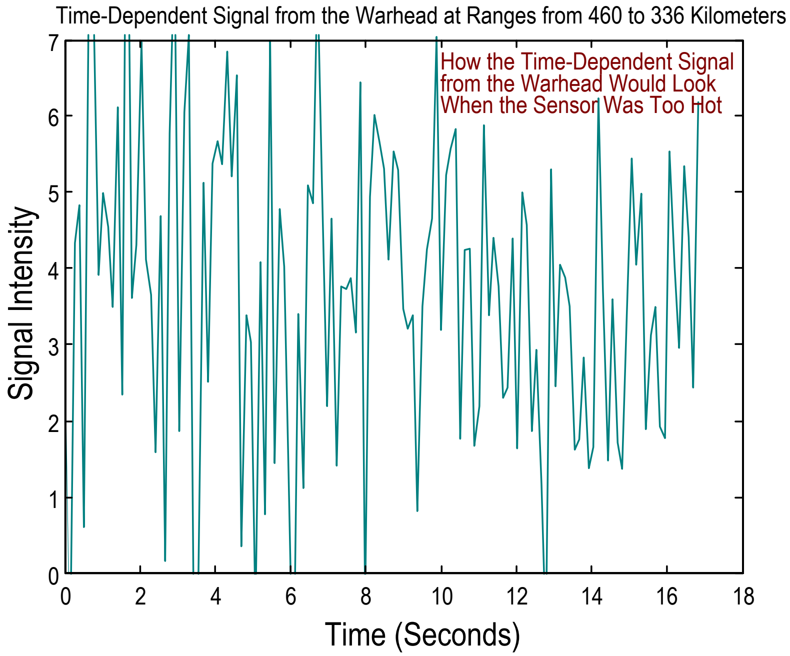


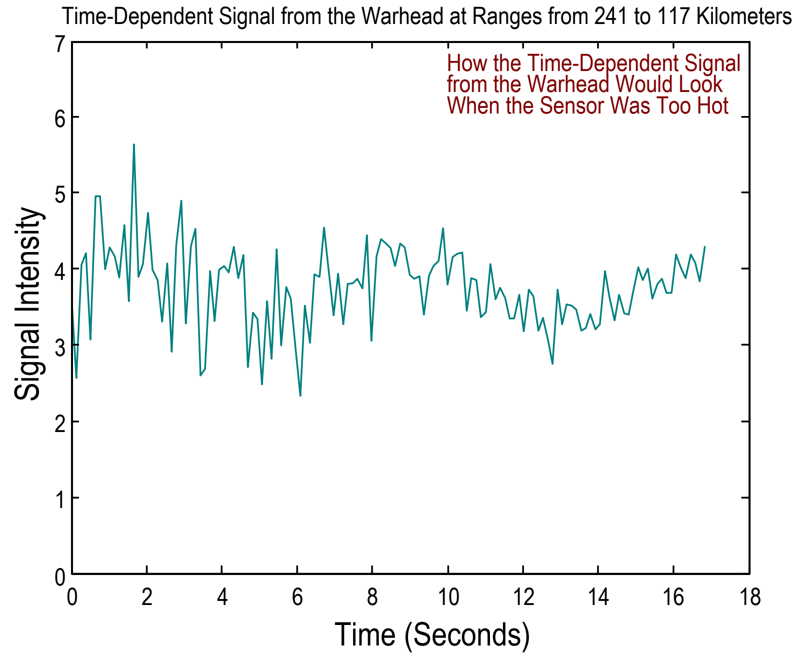


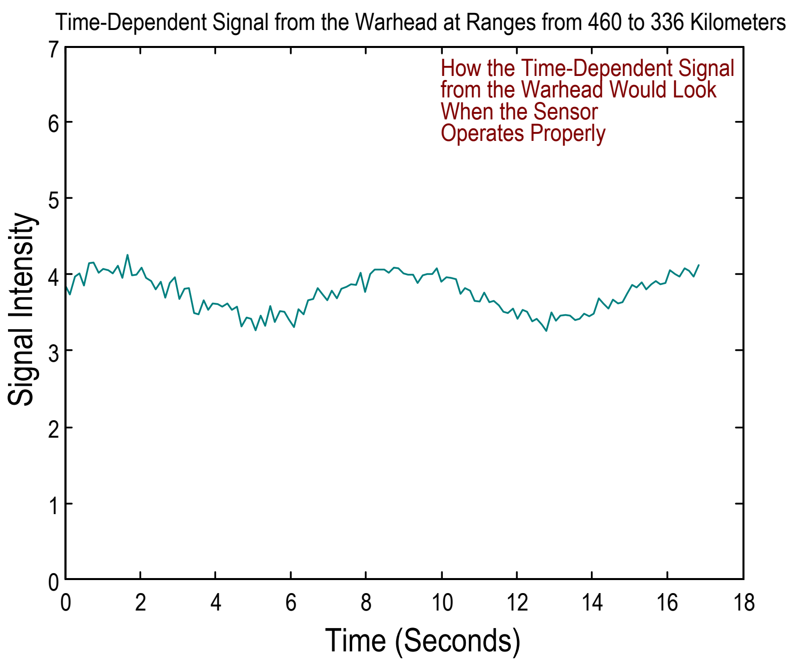
Simulated Appearance of Intended and Actual Warhead Signals

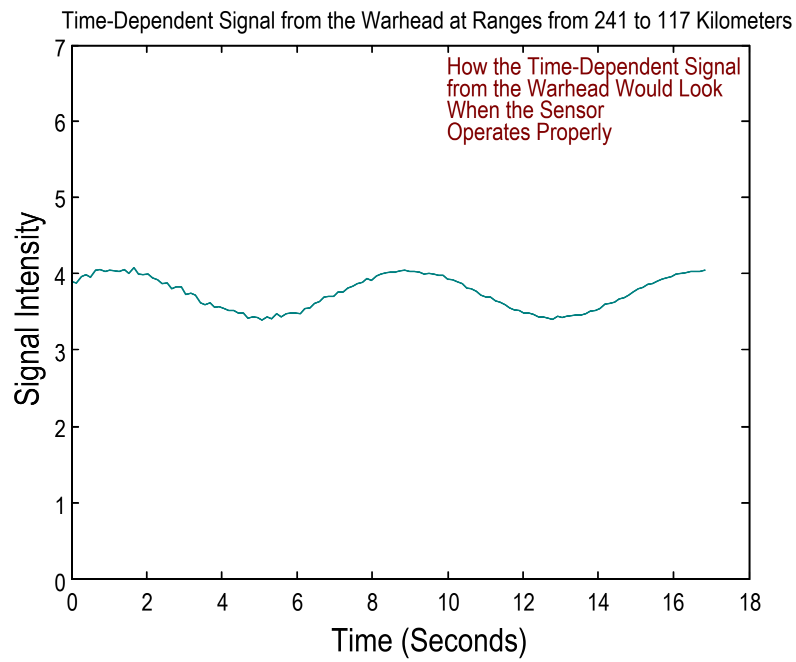


Range and Time-to-Go Dependence of the Infrared Signal from the Warhead









Summary of Effects that Result from the Off-Design Temperature of the Sensor

Summary of Results for the IFT-1A Experiment

BMDO and Contractor Claims:
Experiment was a Complete Success and Demonstrated the Ability to Optically Discriminate Between Warheads and Decoys

Actual Results:
No Usable Data was Collected in the Experiment – The Claims of Success Were Totally Fraudulent

Undisputed Facts Uncovered By Investigators	Consequences of the Undisputed Facts
Exact Temperature of the Sensor Was Unknown, but Was Belatedly Reported to be 20 to 30 Percent Higher than the Intended (Nominal) Operating Temperature	Operating Temperature was 14 °K to 15 °K instead of a Nominal 12 °K For these temperatures Sensor Thermal Noise will be 100 to 200 Times Larger than Nominal
Limited Available Data Shows Actual Noise Level Was 25 to 40 Times Higher Than Nominal	Sensor Acquisition Range Was Reduced from the Nominal Range of 460 Kilometer to a Range of 90 Kilometers or less If Everything Else Worked As Planned (It Did Not), Less Than 12 Seconds of Quality Data Would Have Been Collected Instead of 60 Seconds of Quality Data
Exact Sensor Temperature Was Unknown	Exact Sensor Calibration and Noise Levels was Unknown
Exact Sensor Calibration and Noise Level Unknown	Not Possible to Construct Template for Identification of Targets
Sensor Calibration was Unknown	Not Possible to Identify Targets from Observed Intensities
Standard Deviation of Sensor Noise was Twice that of Standard Deviation of the Actual Signals	Not Possible to Identify Targets from Observed Intensity Scintillations
Data Used by Analysts Had Very-High Noise Levels	Not Possible to Use Kalman Filter to Extract Unique Target Frequencies

Claims Made by Government Officials and Contractors About the Unqualified Success of the IFT-1A Experiment

False Claims Made to the Congress
About the Success of the IFT-1A and IFT 2 Experiments

Opening Statement By *Lieutenant General Lester L. Lyles*, USAF
Director, Ballistic Missile Defense Organization
before the Subcommittee on Defense Committee on Appropriations *(April 22, 1998)*
"During the past year, Mr. Chairman, ***we conducted two very successful*** NMD exoatmospheric kill vehicle - or EKV - ***flight tests***. Two different industry teams supported those efforts and are competing against each other. ***We demonstrated*** in those initial tests ***that we can*** use an EKV sensor to ***identify and track*** objects in space - including ***threat representative targets and decoys*** - and allow us to discriminate and determine what is an actual target and what is not."

Statement of
***Lieutenant General Ronald T. Kadish*, USAF**
Director, Ballistic Missile Defense Organization
Before the
House Armed Services Committee
Subcommittee on Military Research & Development
Thursday, *June 22, 2000*

This significant countermeasures package [in the IFT-1A and IFT-2 experiments] contained more objects than the countermeasures packages we employed during IFT-3 and IFT-4 because ***we wanted to see how well the EKVs could discriminate within the target complex and identify the warhead***. ***We gathered an immense amount of data that increased our confidence in our ability to meet the discrimination challenge***. ***IFT-1A and 2 demonstrated a robustness in discrimination capability that went beyond the baseline threat*** for purposes of designing the Expanded C-1 system.

This phase began with IFT-3, a partially integrated intercept test, when we successfully demonstrated our ability to do on-board discrimination and target selection as well as hit-to-kill.

False Claims Made About the Success of the IFT-1A and IFT 2 Experiments

EKV prototypes discriminate 'spectacularly well,' boeing nmd chief says
Inside Missile Defense, September 30, 1998 -

"[The] particular target complex that these seekers were launched against was a quite sophisticated target complex, far more than we have to handle for an initial deployment," Peller noted. "Without going into details let me say that each seeker, using its own discrimination algorithms, positively nailed the reentry vehicle identified in the set of all those objects. . . . It picked it all up -- objects of all types," he said.

"We went from the case of not having any demonstrated optical discrimination to all of a sudden having an abundance of it."

BMDO BEGINS 'ORDERLY PHASEOUT' OF BOEING BACKUP NMD KILL VEHICLE
Inside Missile Defense, May 19, 2000 -

"We found that in both cases we were able to pick the reentry vehicle out of the target complex. There was just some minor adjustments done after that based on what they learned, but with the data that they had, they were able to pick it out in both cases."

Data from those tests will benefit the NMD program over the next 10 years, Englander noted.

Statement Indicating that Top Management of the Ballistic Missile Defense Organization Knew About Discrimination Problems Identified in the IFT-1A Experiment

"So the decoy is not going to look exactly like what we expected. It presents a problem for the system that we didn't expect,"

Statement of
Lieutenant General Ronald Kadish,
Director of the Ballistic Missile Defense Organization,
while being filmed by 60 Minutes II after learning that
the 2.2 meter balloon misdeployed (did not inflate properly)
during the IFT-5 experiment

False Statements of Success in the Summary of Results Report for the IFT-1A Experiment

Claims in Summary

Sensor operation and data acquisition were nominal

The sensor cooled to operating range with a hold time significantly longer than the required 80 seconds.

Data showed correct sensor operation

[Data] revealed excellent sensor performance in terms of acquisition range as well as radiometric measurement capabilities.

This performance permitted the achievement of the mission objectives related to collection of signature and discrimination data.

No anomalies were observed during the flight or during detailed review of the recorded telemetry.

Facts

Sensor never achieved operating temperature.

Sensor calibration was unknown.

Sensor temperature was unknown

Sensor noise level was 25 to 40 times higher than nominal

Sensor acquisition range was reduced from 460 kilometers to 90 kilometers or less.

Without calibration and data that has a high ratio of signal-to-Noise, no target selection is possible.

2.0 SUMMARY.

2.1 Summary of Results at 60 Days

The SPL flight preparation, which was completed with no anomalies, culminated in the payload preparation and close-out on day L-1. Health of the SPL was excellent at launch. Target vehicle liftoff occurred at 03 hours, 39 minutes, 00.398 seconds UTC. The Payload Launch Vehicle (PLV) was launched at 04 hours, 00 minutes, 34.6 seconds UTC. PLV flyout appeared to be nominal with Time of Closest Approach (TCA) occurring at 501.29 seconds MET. All four PLV to SPL discretes were received, as expected.

The initial assessment of overall performance of the SPL performed at L+48 hours indicated nominal operations and performance, and the complete set (over 1.26 gigabytes) of flight telemetry was recorded. Subsequent review and analysis confirms the excellent performance and nominal operation of all systems on the SPL and Boeing ground support equipment (GSE). Details of the review and analysis is the subject of this report.

Sensor operation and data acquisition were nominal, as monitored during flight and by detailed reviews and analysis of the recorded telemetry data. The telemetry data shows that sensor operation in space was achieved. Sensor operation data was transmitted via the 960 Kbps telemetry link and successfully recorded. Sensor target data was transmitted via the wideband 8,192 Kbps telemetry link and recorded as classified data for later data reduction. All data recording was nominal. The sensor cooled to operating range with a hold time significantly greater than the required 80 seconds. In conclusion, the reduced data showed correct sensor operation during the mission. Recorded data has been analyzed to evaluate the sensor performance and has revealed excellent sensor performance n terms of acquisition range as well as metric and radiometric measurement capabilities. This performance permitted the achievement of the mission ← objectives related to collection of signature and discrimination data.

The navigation subsystem performed exceptionally well during pre-launch and flyout. The GEM GPS receiver functional performance was nominal during pre-launch. Lock-on to four satellites occurred within 2 minutes after the receiver completed self-test. The IMU functional performance was nominal throughout pre-launch. IMU pre-launch monitoring was performed using accelerometer leveling and gyro monitoring. Performance was outstanding; well within one sigma of the specification performance requirement. The GPS receiver maintained track on four satellites incorporating data from all four satellites into its filter. No ← anomalies were observed during flight or during detailed review of the recorded telemetry.

The full verification that all mission objectives were met will be accomplished by continuing analysis of the recorded data. This report provides a discussion of the data and analysis results that were available at the time of its preparation. Final "truth" data has yet to be received and evaluated, and so detailed analyses of ← the flight data will continue. Results of these subsequent analyses will also be infused into the IFT-3 preparation process.

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The Roles Played by Organizations with Oversight Responsibiitlies

Summary of the Roles of BMDO Management and MIT Lincoln Laboratory Report in Coverup of Fraud in the National Missile Defense Program (1 of 2)

BMDO's Role in the Scientific Fraud:

Funded and Managed the MIT Lincoln Laboratory Report as a Device for "Proving" that no Fraud Occurred.

At Best, BMDO Can Argue they were not Competent to Know that the MIT Lincoln Laboratory Report was Based on Fraudulent Science.

More Likely, BMDO Management Knowingly Commissioned the MIT Lincoln Laboratory Report to Cover-up BMDO Management's Complicity, Knowledge, and Active Participation in the Scientific Fraud.

Department of Justice's Role in the Scientific Fraud:

The Department of Justice (DoJ) was Fully Informed of the Pervasive and Substantial Evidence of Fraud by Investigators of the Defense Criminal Investigation Service (DCIS), the Investigative Arm of the Department of Defense Inspector General (DoDIG). The Department of Justice accepted the MIT Lincoln Laboratory Report as a scientific analysis that showed no fraud occurred. The DoJ made no attempt to have an independent review of the Lincoln Laboratory Report. The Department of Justice knew that the MIT Lincoln Laboratory Report was paid for and supervised by the BMDO, and that the BMDO top managers had obvious conflicts of interest and could well have been motivated to cover up the fraud.

Department of Defense Inspector General's Role in the Scientific Fraud:

The Department of Defense Inspector General (DoDIG) had an extensive ongoing investigation of the contractor, TRW. The letters issued by the DoDIG investigator in the field indicated that he and his colleagues believed there was extensive evidence of fraud by the contractor. The field investigator had also indicated that he had serious concerns about the independence of Nichol's Research, which on behalf of the BMDO, had supposedly examined the technical problems that led to the allegations of fraud. In response to the concerns of the DoDIG investigator that Nichol's was not independent, the BMDO commissioned, paid for, and oversaw a second allegedly independent review of the scientific issues that led to the allegations of fraud, this time performed by the MIT Lincoln Laboratory. The second review was, for reasons that remain unclear, accepted by the main office of the DoDIG as an independent finding that showed that fraud had not occurred. The DoDIG Main Office then ordered that the field investigation be stopped.

Summary of the Roles of BMDO Management and MIT Lincoln Laboratory Report in Coverup of Fraud in the National Missile Defense Program (2 of 2)

Federal Bureau of Investigation's Role in the Scientific Fraud:

The Federal Bureau of Investigation (FBI) falsely claimed that it had investigated the allegations of fraud in response to a letter signed by more than 50 members of the House of Representatives. The FBI lied to Congress when it claimed that it coordinated its investigation with the General Accounting Office. In fact, the FBI had only one meeting with GAO investigators. The FBI/GAO meeting occurred *before* the GAO had obtained any of the documents it had requested from the Department of Defense for its investigation. At this point in time, the GAO had essentially no information to share with the FBI from an investigation, yet the FBI told the Congress that the FBI had coordinated its investigation with the GAO.

MIT Lincoln Laboratory's Role in the Scientific Fraud:

The MIT Lincoln Laboratory managed a study under contract to the BMDO that claimed to be a scientific analysis that showed no fraud occurred. However, a simple review of the scientific content of the study shows that the study's conclusions were neither supported by the data or analysis contained in the study. The GAO reported that Lincoln Laboratory knew that there were "large errors in measurement accuracy" of the infrared sensor in the IFT-1A due to the sensor not achieving its operating temperature and due to the sensor's constantly changing temperature during the measurement interval. The high temperature of the infrared sensor also resulted in very severe "thermal noise" contamination of the infrared data. These effects made the data from the experiment unusable, but were not even mentioned in the Lincoln Laboratory Report. The GAO also found that the MIT Lincoln Laboratory investigators "did not verify the accuracy of [the] data provided by [the contractor]" and therefore "did not … prove or disprove the contractor's claim" that fraud had not occurred.

The Role of the MIT Administration's in the Scientific Fraud:

The MIT Administration operates Lincoln Laboratory for the Department of Defense. The Director of Lincoln Laboratory is appointed by the MIT Administration and is a member of the MIT Faculty. The President, Provost, and Chair of the MIT Corporation were all fully informed by a senior member of the Faculty about the false and misleading findings in the Lincoln Laboratory Report, and that the Lincoln Laboratory Report was used to stop Department of Justice and Department of Defense Inspector General Investigations of fraud. The MIT Administration did not respond to the repeated warnings of the faculty member until their inaction was discussed in the press.

Actual Results:

No Usable Data was Collected in the Experiment – The Claims of Success Were Totally Fraudulent