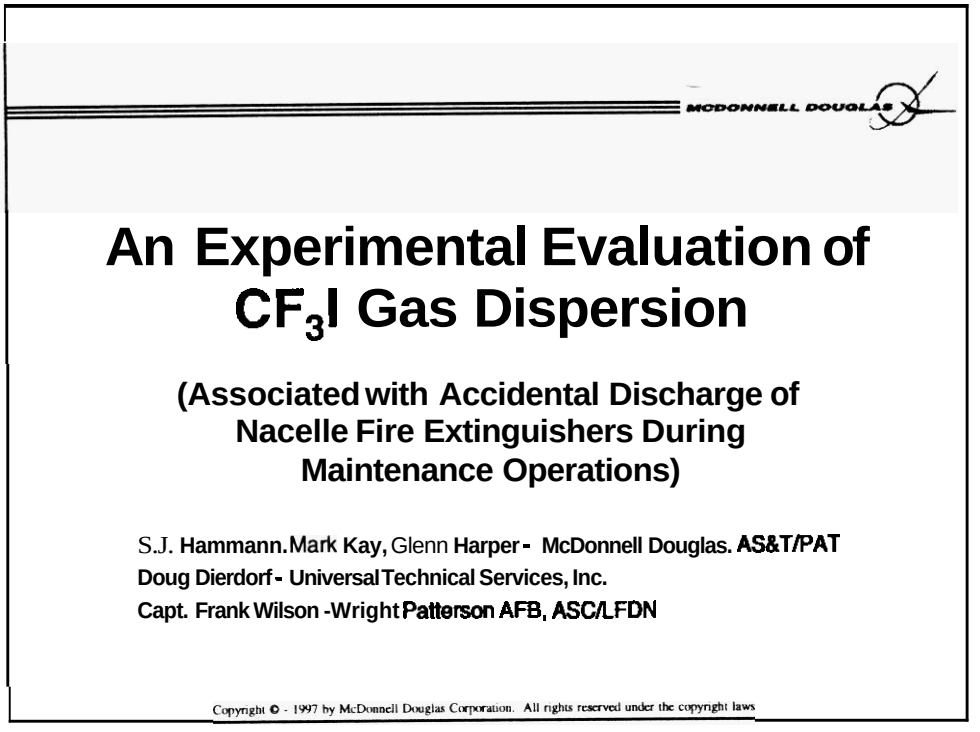

Participating Oganizations:

- F-15 SPO -- ASC/LFDN WPAFB (Capt. F. Wilson)
- WR-ALCRFM (J.D. Brown)
- WL/FIVCTF Tyndall AFB (D. Nelson)
- Bio-Rad (C. Lins)
- Pacific Scientific (D. Dierdorf. D. VanOstrand)
- McDonnell Douglas, AS&T/PAT Phantom Works
  (S.J. Hammann, M. Kay, L. Shawgo)

CF_3I Discharge Test 12/96

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- Photograph of test F-15A in Paint Hanger at Robins AFB.
- F-15A used for test is the aircraft used normally for painting training.
- Simulated engine installation in test nacelle for realistic clutter affects.
- The purpose of this testing is to quantify the potential for a ground crew's exposure to CF_3I during an inadvertent discharge of this fire suppression agent.

Test Instrumentation

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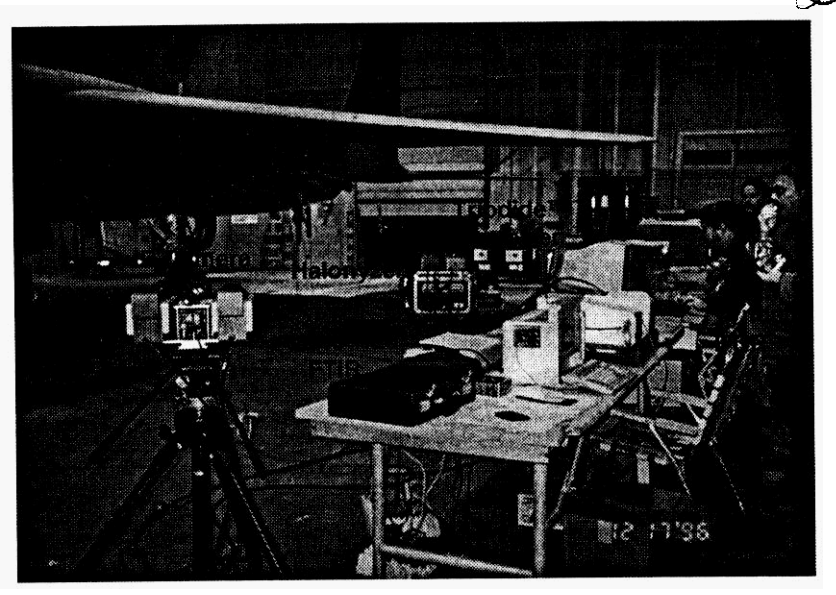
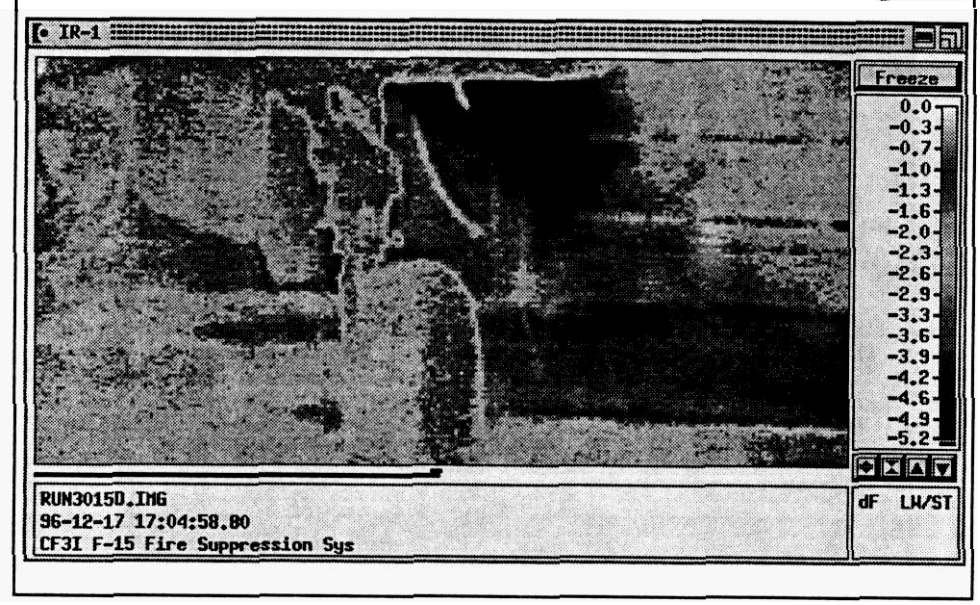


- Photograph of instrumentation bench and F-15A.
- Halonyzer - 12 channels, 0.1 Hz sample rate, ± 0.2 Vol % theoretical accuracy.
- **Triodide™** Analyzer - 6 channels, 10 second sample cycle, ± 0.0125 Vol %
- Bio-Rad FTIR and Tyndall AFB FTIR - 1 channel each, sample rate 0.1 Hz to 3 Hz, Resolution: 4 cm^{-1}.
- Infrared measurement equipment
  - 20 Degree Field Of View Lenses. Geometric Resolution: 1.5 mrad Long Wave Imager, 1.7 mrad Short Wave Imager.
  - Frame Frequency: 15Hz. Digital Acquisition Rate: Approximately 1 - 2 Hz.
  - Long Wave Imaging Head (the best for CF_3I visualization)
    - Wavelength Range: 8 - 12 µm
    - Temp. Range: -30 - +1500 °C, 0.08 Degrees C @ 30 °C Sensitivity
    - Accuracy: +/-1 Degree C on lowest range, +/-1% on higher ranges
    - Resolution: 272 Samples Per Line (230 elements/line @ 50% modulation), 136 Lines
- **Note:** The actual test environment, test method, location of background data collection and calibration will have an impact upon the accuracy of sensed CF_3I

97/5/1

Open Nacelle - Digital Infrared (IR)
(Differential Image)



- A differential IR image provides enhanced imaging of CF_3I plume.
  - Created by subtracting the digital data from the sample just prior to the CF_3I discharge from the current image's digital data to remove the background temperature.
  - The resulting image reveals changes in temperature resulting primarily from the CF_3I plume dissipation.

Agent Discharge at LOAEL

(Cardiac Sensitization)

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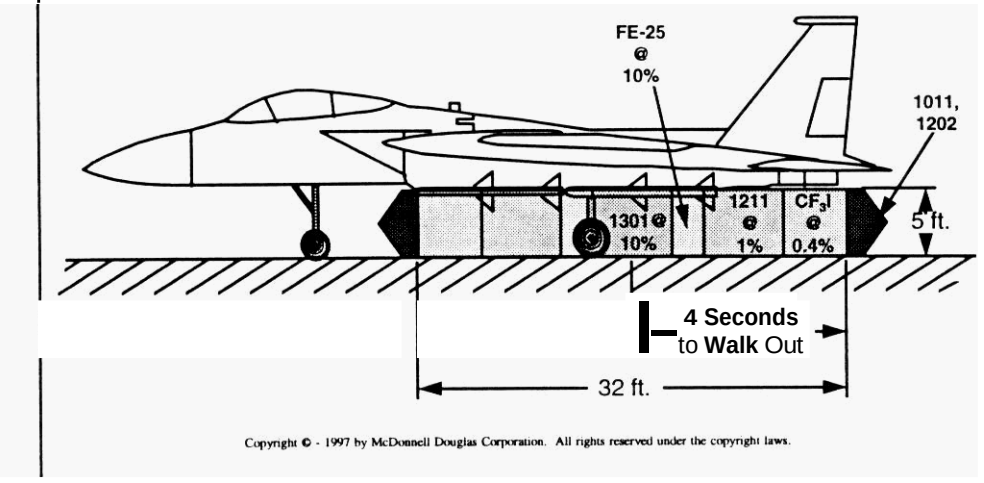

- The potential hazard to the crew is their exposure to a plume of CF_3I gas inadvertently released in one of the engine nacelles during maintenance operations, or pre-take-off inspection.
- This simple analysis shows that a homogenous CF_3I plume at the LOAEL concentration is a reasonably small size indicating a need for further investigation by test.

Crew Locations Considered

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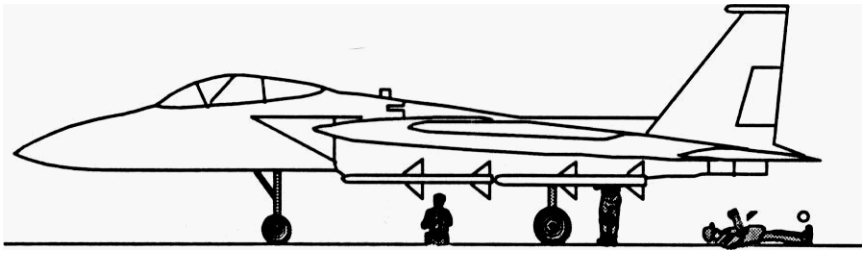


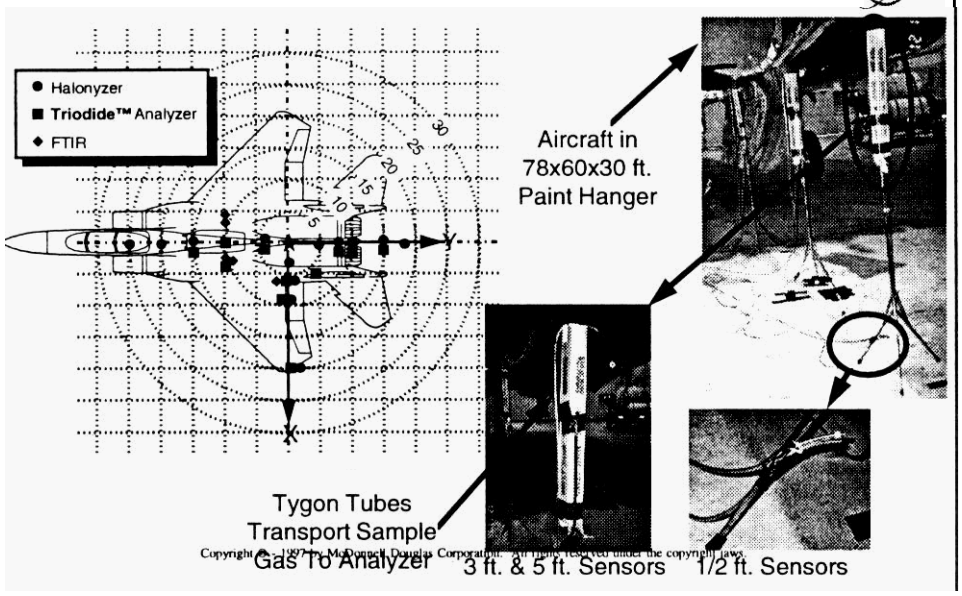
KNEELING OR STANDING NEAR ENGINE BAY

WORKING IN OR UNDER ENGINE BAY

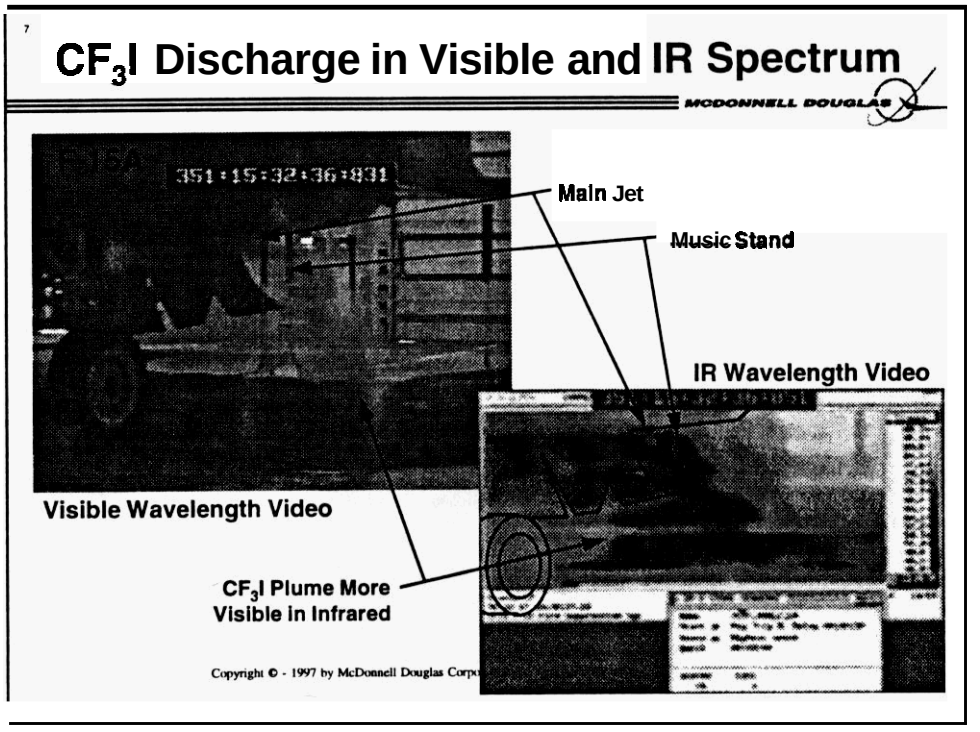
LAYING NEAR ENGINE BAY

- These locations show possible areas for maintenance close to the fire suppression bottle discharge nozzle.
- These locations are at **risk** for inadvertent exposure to CF_3I and therefore define the locations for potential human exposure.
- Four tests were conducted with sensor located and then relocated between tests to characterize crew exposure levels.
- Three tests were conducted with the engine nacelle doors open. One test was conducted with the engine nacelle doors closed.

Open Nacelle - Sensor Coverage



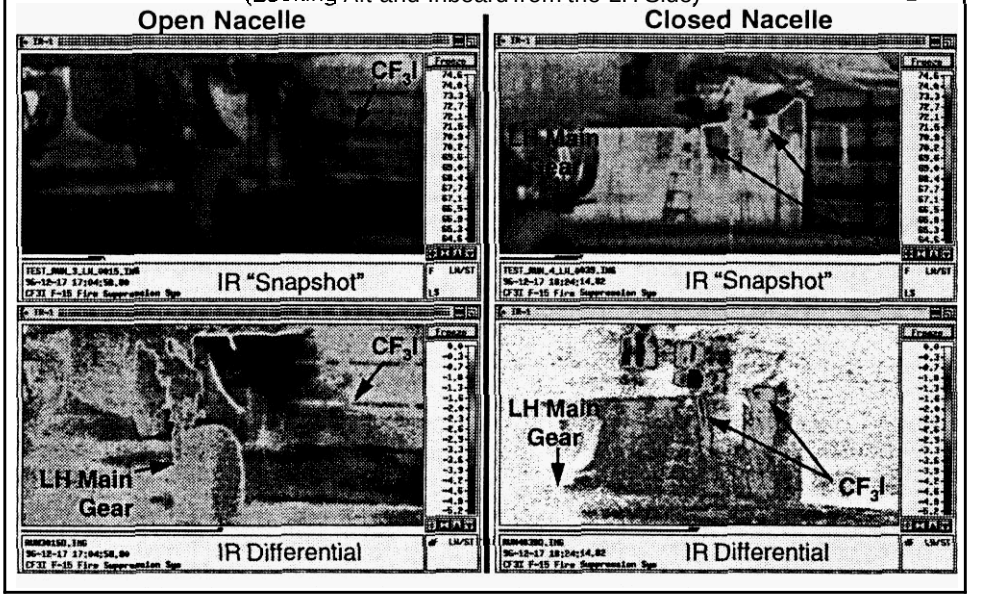
- **All** gas analyzers draw gas samples through tygon tubing to the actual sensing element. The ends of the tubing were located in position utilizing music stands and blocks.
- Sensor inlets were located at various radii from the gas discharge nozzle at 1/2, 3, and 5 feet elevations.
- The sensor coverage graphic shows the location of all valid sensor inlets during the three discharges with the nacelle doors open.



- Visible spectrum video taken at same location as IR Video.
- Visible spectrum video image of CF_3I plume is actually an image of water condensation resulting from the cold agent discharge.
- IR video shows more of CF_3I plume than visible spectrum video.
- IR Video image results from the combination of temperature variations, CF_3I absorption of background IR, and CF_3I IR emittance.

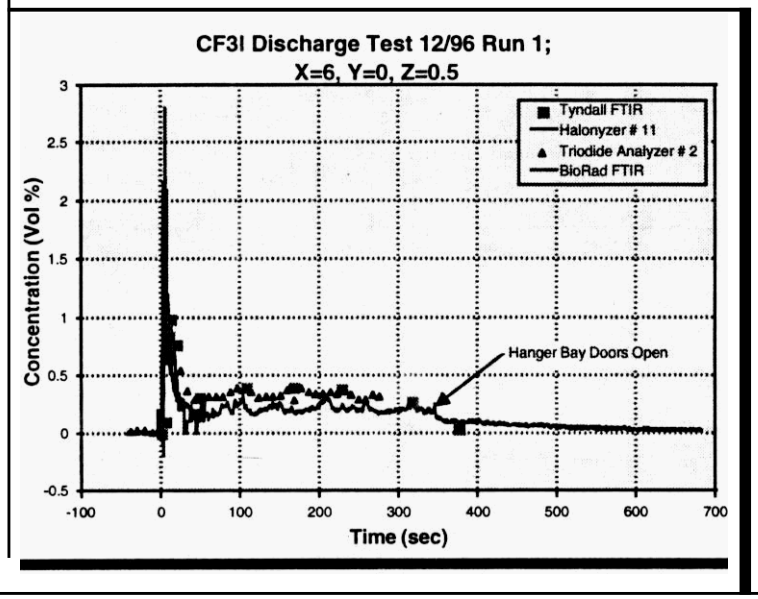
Digital Infrared Visualization

(Looking Aft and Inboard from the LH Side)



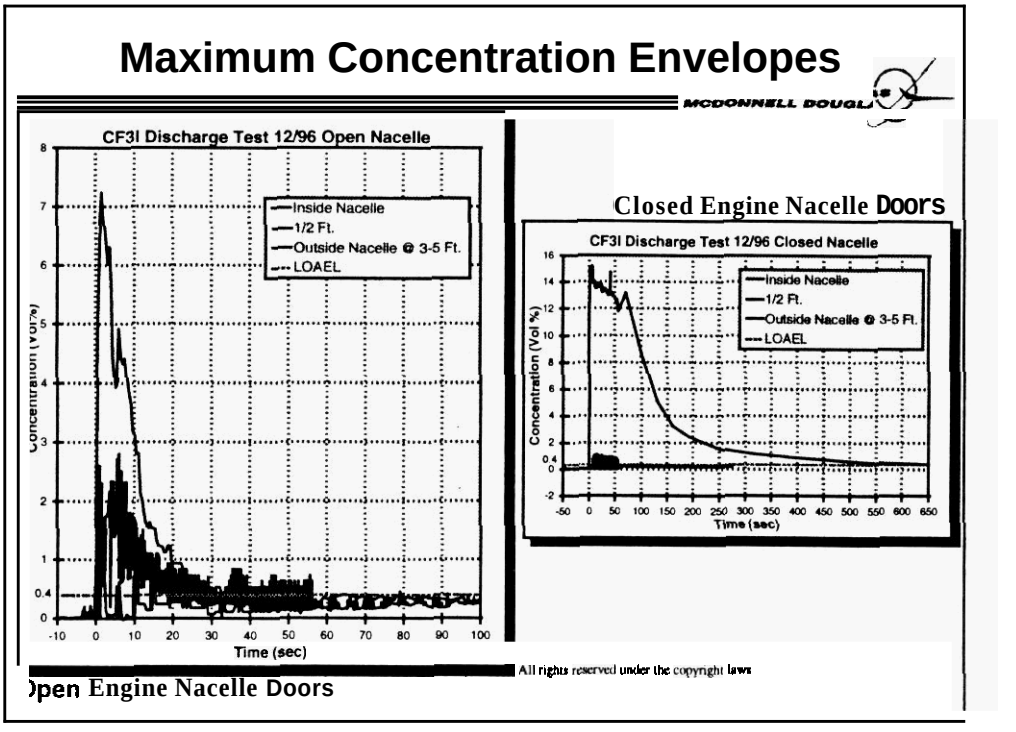
- Comparison of "snapshot" IR images and differential images for the same time frame.
- Representative images are shown for both the open nacelle testing and the closed nacelle testing.
- Note the CF_3I flowing out nacelle openings in the closed nacelle images.

Sensor Comparison - Same Location



- One sensor inlet from each of the four gas analyzers were located together during the first discharge with the nacelle doors open.
- The data shows reasonable correlation between the four gas analyzers.
- Results indicate that improved correlation can occur if the same gas sample is used to calibrate each analyzer, background data collected using a common method, the time synchronized between each gas analyzer's clocks, and a "time of event" trigger developed.
- The Tyndall FTIR and Triodide™ Analyzer require semi-manual interpretation of data to calculate the plotted points.

Maximum Concentration Envelopes



- These curves present the overall worst case concentration time history in the engine nacelle, outside the nacelle between 3 to 5 feet elevation, and outside the nacelle at 1/2 foot elevation, for discharge cases with open engine nacelle doors and closed engine nacelle doors.
- These curves were derived using data from all sensors at the desired elevation and either inside or outside the nacelle. Radial distance from the discharge nozzle was not considered in order to produce the most conservative concentration levels.
- These curves are the basis for determining the estimated human absorption during an accidental discharge with the engine nacelle open for comparison to the agent's **LOAEL.**
- **All** data at specific locations as well as summary data was provided to ManTech, Armstrong Labs for analysis.

Conclusions

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- CF_3I Plume Disperses Rapidly
- Discharge Follows Nozzle Pattern and Settles to Floor
- Exposure Levels Drops Below the LOAEL Quickly
  - Inside Nacelle Less than One Minute
  - Outside Kneeling or Standing Less Than 20 Seconds
  - Outside Laying Down Less Than 30 Seconds
- Human Exposure Under Evaluation Now

Participating Organizations

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- Our thanks to the support provided by all participants who provided test equipment, agent samples, personnel, and their time.
- Special thanks is addressed *to* the F-15 community and the maintenance organization at Robins Air Force Base.