Completed Project (2013 - 2014)

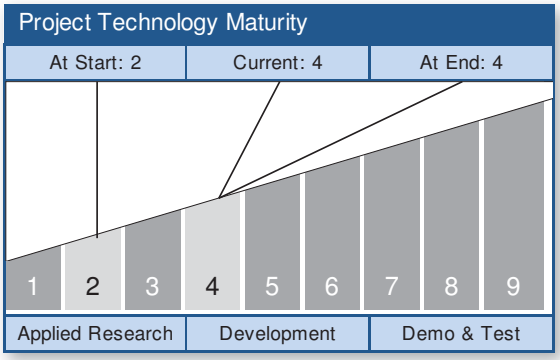
Hydrogen Fire Spectroscopy Issues Project

Center Independent Research & Developments: KSC IRAD Program

Mission Support Directorate (MSD)

National Aeronautics and Space Administration

Liquid hydrogen is carried to the launch pad through a cross country line from an 850,000 gallon (3,200,000 L) storage tank. The vertical column is the flare stack where hydrogen boil-off is burned. The Atlantic Ocean is in the background.



ABSTRACT

The detection of hydrogen fires is important to the aerospace community. The National Aeronautics and Space Administration (NASA) has devoted significant effort to the development, testing, and installation of hydrogen fire detectors based on ultraviolet, near-infrared, mid-infrared, and/or far-infrared flame emission bands. Yet, there is no intensity calibrated hydrogen-air flame spectrum over this range in the literature and consequently, it can be difficult to compare the merits of different radiation-based hydrogen fire detectors.

Technology Area: TA (Primary)

ANTICIPATED BENEFITS

To NASA funded missions:

All missions that require a hydrogen fueled launch will benefit from this work. Having a better understanding of the emission spectrum of a hydrogen flame allows better design and evaluation of hydrogen flame detectors. Also, having a modernized

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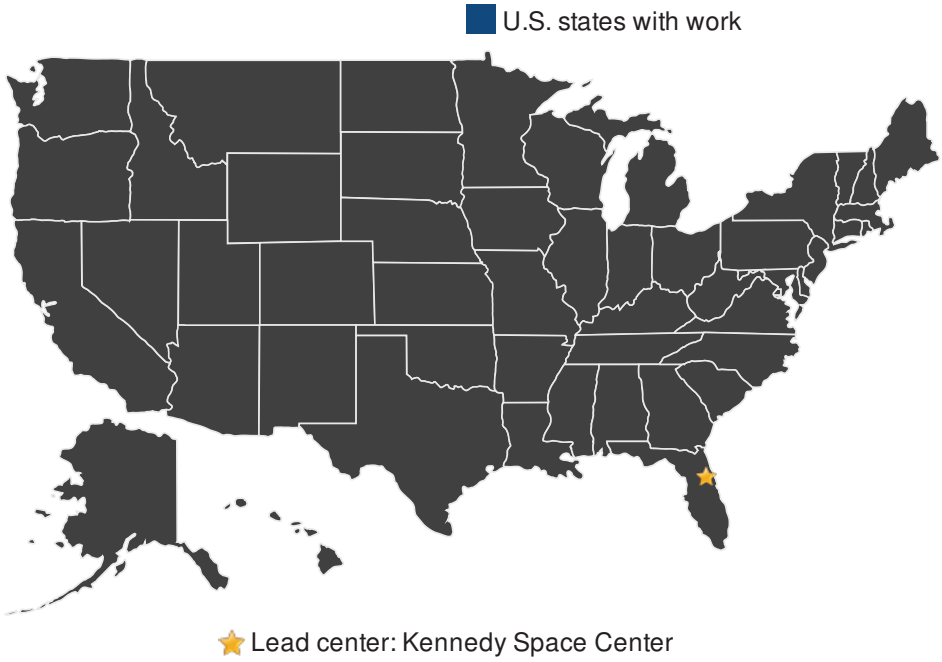
Read more on the last page.



Contributing Partners	Ground Systems Development and Operations Program

DETAILED DESCRIPTION

This one year effort had four aspects; complete and document the calibrated spectral intensity of a hydrogen flame, understand the role of atmospheric attenuation on the performance of hydrogen flame detectors, help qualify the performance of the near infrared water measurement instrument used in the NASA Regolith and Environment Science and Oxygen and Lunar Volatile Extraction (RESOLVE) project, and build a prototype next-generation ultraviolet hydrogen flame simulator.

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Read more on the last page.

MANAGEMENT

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Principal Investigator:
Robert Youngquist

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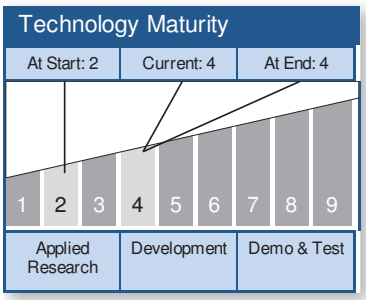
TECHNOLOGY DETAILS

An Ultraviolet Hydrogen Flame Simulator



TECHNOLOGY DESCRIPTION

NASA is one of the largest consumers of hydrogen in the world. The Apollo Program Saturn V Rocket second stage held 70,000 kg of liquid hydrogen, the Space Shuttle External Tank held over 100,000 kg of liquid hydrogen, and the proposed future Space Launch System liquid hydrogen tank will likely exceed these quantities. During the Space Shuttle Program NASA's Kennedy Space Center (KSC) alone purchased approximately 900,000 kg of liquid hydrogen annually all of which had to be transported and stored; and then routed via a cross country line on its way to the launch vehicle. Much of KSC's hydrogen infrastructure was constructed in the 1960's and is located near the ocean, a corrosive environment, so both hydrogen leak and hydrogen fire detection have been given serious attention.

This project allowed us to design, construct, and test a prototype ultraviolet hydrogen flame simulator to replace the one we developed in the early 1990s.

This technology is categorized as a hardware assembly for ground support or mission operations

- Technology Area
    - TA13 Ground & Launch Systems Processing (Additional)

CAPABILITIES PROVIDED

This tool can be used at the launch pad to certify the proper operation of the ultraviolet based hydrogen flame detectors. The earlier version we developed in the 1990s became a critical component in the certification of the launch pad fire detection system.

POTENTIAL APPLICATIONS

This device can be used to simulate the ultraviolet emission of a KSC standard hydrogen flame and thus used to perform certification checks on the performance of ultraviolet based hydrogen flame detectors.

Performance Metrics		
Metric	Unit	Quantity
reduced power consumption	%	50

PROJECT LIBRARY

Images

- Liquid hydrogen carried to KSC launch pad through a cross country line.

  (https://techport.nasa.gov/fetchFile?objectId=4035)

Peer Reviewed Papers

- Intensity Calibrated Hydrogen Flame Spectrum

ANTICIPATED BENEFITS

To NASA funded missions: (CONT'D)

ultraviolet hydrogen flame simulator will aid in the certification of the flame detection system at the launch pad being used.

To the commercial space industry:

All missions that require a hydrogen fueled launch will benefit from this work. Having a better understanding of the emission spectrum of a hydrogen flame allows better design and evaluation of hydrogen flame detectors. Also, having a modernized ultraviolet hydrogen flame simulator will aid in the certification of the flame detection system at the launch pad being used.

DETAILED DESCRIPTION (CONT'D)

- We obtained a calibrated ultraviolet lamp and worked with safety to permit its use. Using this we were able to calibrate our spectrometer for ultraviolet measurements and successfully measured the UV emission of a hydrogen flame. This completed our spectral measurement (we had previously performed measurements from the visible through the far-infrared under program funding). We have documented this effort in a new technology report and in a manuscript that we submitted to the International Journal of Hydrogen Energy. This paper has been accepted for publication and appeared in the June 2014 issue of the International Journal of Hydrogen Energy.

- We set up an extended tube and filled it with humid air in order to perform some atmospheric absorption measurements. The results have indicated that the new infrared radiation (IR) fire detectors should operate within their design distance even in humid Florida air.

- We have provided significant aid to the Resolve project. We took preliminary data before the spectrometer showed up, we performed analysis, we helped interpret the data provided by their spectrometer, and we've helped to develop an algorithm to convert their spectral absorbance data into a water vapor concentration.

- We have designed, constructed, and tested a new prototype ultraviolet hydrogen flame simulator. A new technology report has been written and we will be working with KSC Ground Support Development to start the conversion of this device into ground support equipment so that it can be used to certify the ultraviolet fire detectors still being used in the field.