

Travis Air Force Base



# Development of a Point of Care Technology for Military Medical Applications in Austere Environments

David J. Loftus, M.D., Ph.D., Jing Li, Ph.D., Tore Straume, Ph.D.

NASA Ames Research Center

Matt Coleman, Ph.D., Matthias Frank, Ph.D., Erik Mukerjee, Ph.D.

Lawrence Livermore National Laboratory

M. Austin Johnson, M.D., Ph.D., Ian Stewart, M.D.

Clinical Investigation Facility, David Grant Medical Center, Travis Air Force Base

## ABSTRACT

NASA, Lawrence Livermore National Laboratory (LLNL) and the Department of Defense (DoD) share a common interest in compact medical diagnostic technologies—also known as “point of care testing” (POCT) technologies. For NASA, the need is to take care of astronauts on deep space missions. For LLNL, the focus is on technologies needed to support homeland security applications. For DoD, the need is to support warfighters in military theaters of operation, especially for *prolonged field care* and *en route care*.

A recently patented technology, “Portable Medical Diagnosis Instrument” (U.S. Patent 9824870), co-invented by NASA and LLNL, is being developed further in a partnership between NASA, LLNL and Travis Air Force Base, with a focus on military applications. This instrument, the NASA-LLNL Medical *Tricorder*, can be used for a wide range of clinical samples including breath, saliva and blood. One component of the *Tricorder* is the NASA E-Nose, a carbon nanotube-based chemical sensor, integrated into a hand-held smart phone, that can detect and measure “breath biomarkers” in the gas phase of exhaled breath. The response of the NASA E-Nose is rapid, which makes it possible to detect various gas-phase substances in real time. The NASA E-Nose, with modification, can also be used for breath condensate analysis.

Another component of the *Tricorder* is a miniaturized microfluidic analyzer, under development by LLNL, that does not require any pumps. The microfluidic analyzer can detect and measure biomarkers in liquid samples, such as blood, saliva and breath condensate. This microfluidic system requires small quantities of liquid sample and can perform analysis very rapidly (seconds to minutes), which makes it possible to detect relevant biomarkers in near real time in the field.

The **Clinical Investigation Facility (CIF)** at **Travis Air Force Base** is currently conducting research with the goal to develop improved field-able technologies and procedures for the emergency response to life threatening injuries soldiers may receive in theater. This work includes experimental large animal systems and comprehensive collection of clinical specimens and physiological data. NASA and LLNL are partnering with Travis to test and further develop the *Tricorder* technology for high priority military applications, initially focused on lung injury models and traumatic brain injury.

## INTRODUCTION

Point of care (POC) diagnostic technology has the potential to provide critical information needed to improve *in theater* medical care, especially care that extends beyond the “Golden Hour” (*prolonged field care* and *en route care*). Although no POC technology can fully replace the capabilities of a fully equipped clinical laboratory, measurement of key biomarkers can be extremely helpful, especially those that reveal damage to specific organ systems, for both trauma patients and non-trauma patients.

While POC technology based on single, component technologies is the norm, we present here a novel technology that combines *two* component technologies—a breath analysis technology and a microfluidic system. This strategy results in an instrument with far more diagnostic capability than would be possible with just a single component technology, including the ability to analyze both minimally invasive specimens (blood) and non-invasive specimens (breath and saliva).

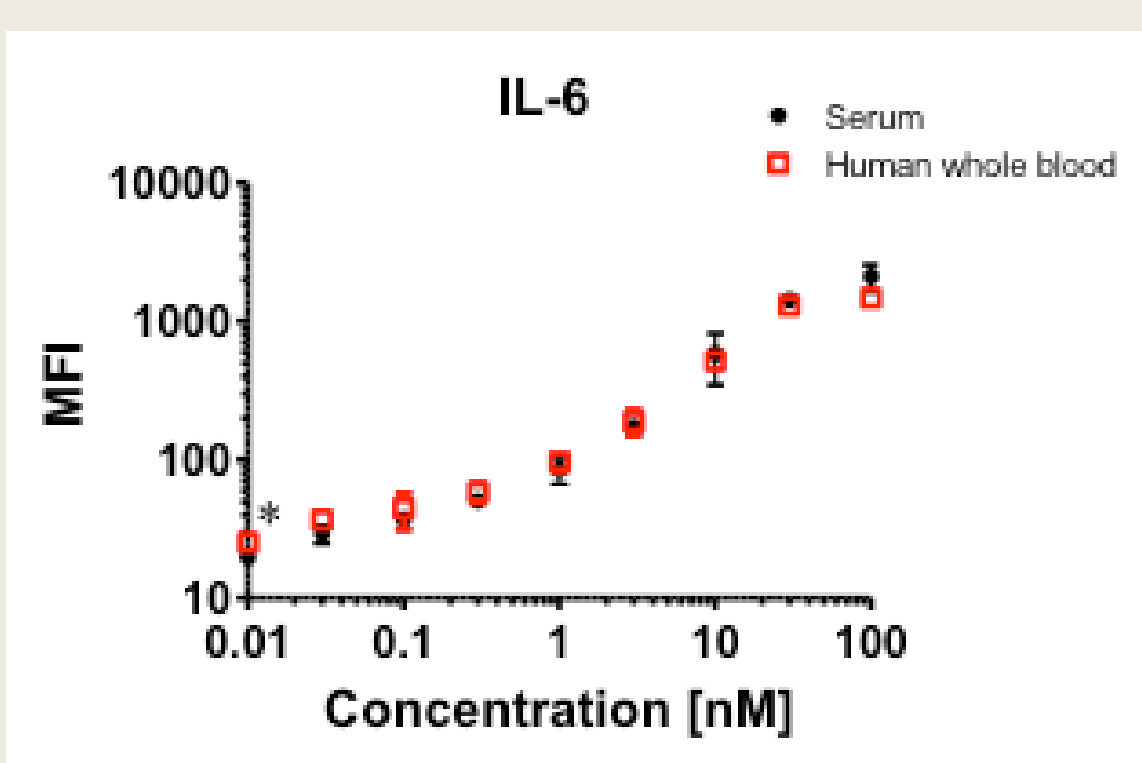
## TECHNOLOGY DESCRIPTION



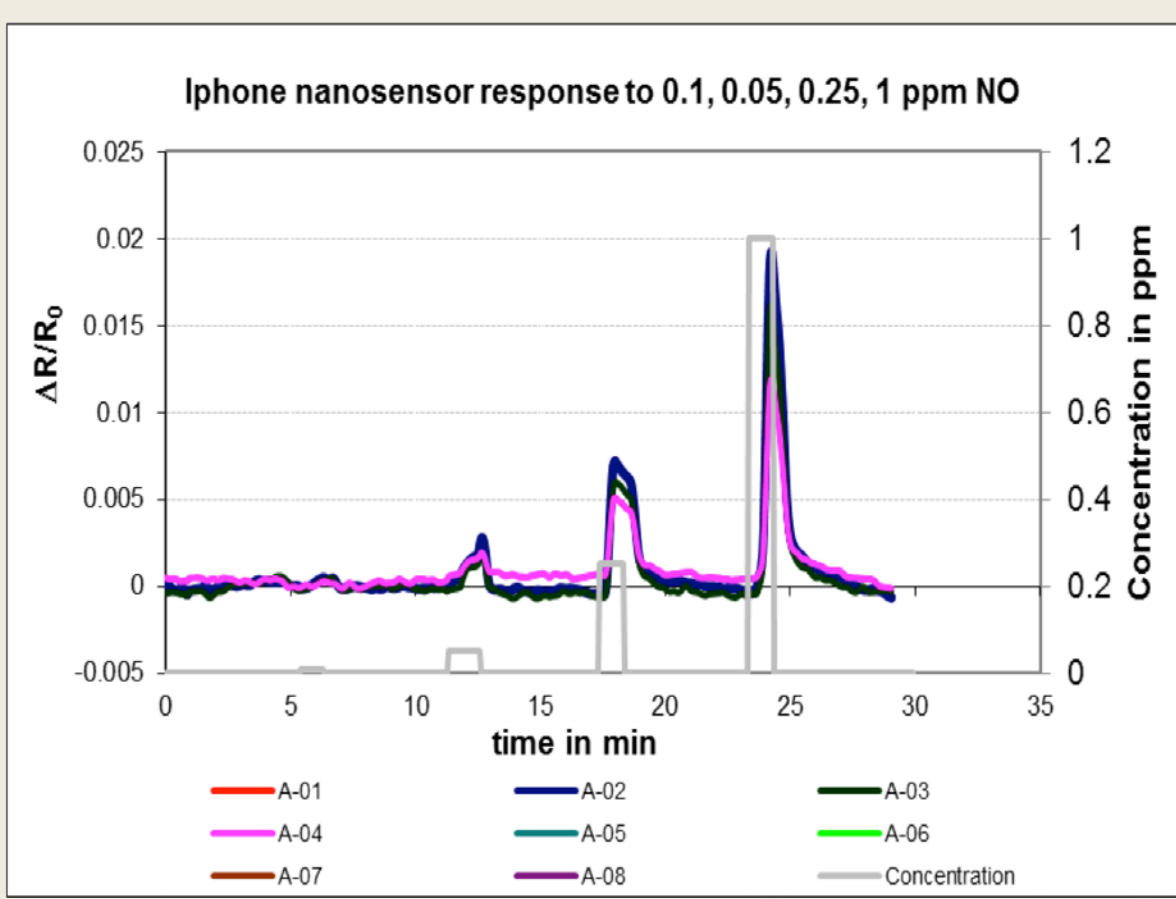
NASA-LLNL Medical “Tricorder”

- The NASA-LLNL Medical Tricorder is a strategic combination of two proven technologies—a LLNL-developed microfluidic system (left) and a breath analysis system (NASA E-Nose) shown on the right.
- Each component has been under development for 10+ years.

The **Microfluidic System** makes measurements on 50-100  $\mu$ l blood samples, or comparable volumes of saliva, and is capable of enumerating blood cells and performing a white cell differential, or measuring peptides/proteins in the sample. Hydrophobic valves control fluid movement driven by centrifugal force.



The **NASA E-Nose** breath analysis system uses carbon nanotube sensor elements on a silicon chip to detect a variety of volatile compounds. The multiplexed system uses machine learning algorithms to interpret the differential response of the sensor elements to analyze exhaled breath specimens for specific biomarkers.



## DISCUSSION

- Compact size, low mass and ruggedness define the chief characteristics needed for Point of Care (POC) diagnostic instruments needed by NASA, Homeland Security and Military Medicine.
- The NASA-LLNL Medical Tricorder is capable of measuring broad classes of biomarkers: blood cells (complete blood count, white cell differential), breath volatiles, and a wide spectrum of peptides and proteins from blood, breath and saliva.
- Current projects just getting underway include biomarker analysis in disease models for *acute respiratory distress syndrome (ARDS)*, *pulmonary contusion (blast injury)* and *sepsis* in experimental pigs at the CIF at Travis Air Force Base.
- Other disease models of interest include models of traumatic brain injury (TBI), acute renal damage and other forms of battlefield-related disease, as well as tropical diseases and other infections.

## SUMMARY

- The NASA LLNL Medical Tricorder combines two proven technologies—NASA E-Nose for breath analysis and a LLNL-developed microfluidic system—for comprehensive analysis of biomarkers to support far forward military medical needs.

## CONTACT

David Loftus  
NASA Ames Research Center  
(650) 814-9181  
[David.j.loftus@nasa.gov](mailto:David.j.loftus@nasa.gov)