# NEXT-GENERATION FIRE SUPPRESSION TECHNOLOGY PROGRAM (NGP) A STATUS REPORT

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## A. The NGP

The Department of Defense has initiated an 8-year, $46 million research program to develop new fire suppression technologies for the replacement of halon 1301 in weapon systems. The goal of the NGP is to develop and demonstrate, by 2004, halon 1301 alternative technologies that are easily retrofitable into currently fielded weapon systems (i.e., within their form, fit, and function constraints). The processes, techniques, and fluids pursued in the NGP must be economically feasible, environmentally acceptable, and user-safe; while meeting the operational requirements now satisfied by halon 1301 systems in current aircraft, ships, and land combat vehicles. If successful, the NGP could eliminate DOD dependence on a substance no longer in national production and minimize any readiness impacts that could result if halon 1301 use restrictions were imposed in the future. The NGP will develop and demonstrate next-generation technologies to a level that will enable DOD weapon system managers to make prudent decisions based on cost, **risk,** schedule, and capability needs. Real-scale validation testing will demonstrate the readiness of these alternative technologies for system applications; however, this program will not develop fire suppression systems for specific weapon systems.

The NGP consists of 24 Elements divided among *6* Technology Thrusts:

1. **RISK ASSESSMENT** AND **SELECTION METHODOLOGY:** Development of a process for choosing among alternative technologies by applying modem decision-making concepts.

2. **FIRE SUPPRESSION PRINCIPLES:** Establishment of mechanisms of flame extinguishment using detailed experimental studies and computational models.

3. **TECHNOLOGY TESTING METHODOLOGIES:** Selection, adaptation, or development of test methods and instrumentation to obtain data on the effectiveness and properties of new suppression approaches.

4. **NEW SUPPRESSION CONCEPTS:** Definition of new ideas for fire suppression based on chemical and physical principles.

5. **EMERGING TECHNOLOGY ADVANCEMENT:** Acceleration to maturity of fluids,

processes and techniques that are already under development.

*6.* **SUPPRESSION OPTIMIZATION:** Development of knowledge to obtain the highest efficiency of each candidate technology.

## B. FY1997 Program

After receiving competitive proposals from both government and non-government organizations, ten projects have been selected to begin in FY1997 and are now underway:

1.a. DEVELOPMENT OF MODEL FIRES FOR FIRE SUPPRESSION RESEARCH
Principal Investigator: Anthony Finnerty, ARL
Associate Investigators: Michael Bennett and Juan Vitali, WL; Ronald Sheinson, NRL

Objective: Construct a small set of model fires, based on understanding of the specific types of DoD fires and their incidence data, and tabulate the constraints of current halon 1301 systems to serve **as** foci for the other research elements.

Principal Deliverable: Same as Objective

2.a. MECHANISMS OF ULTRA-HIGH EFFICIENCY CHEMICAL SUPPRESSANTS
Principal Investigator: Kevin McNesby, ARL
Associate Investigators: Andrzej Miziolek, and Robert Daniel, **ARL;** Mitchell Smooke, Yale; Wing Tsang, NIST

Objective: Determine how chemicals that are as or more efficient than halon 1301 quench the various flames that are of military interest.

Principal Deliverables: Identification of the most vulnerable steps in flame propagation chemistry; key properties of chemicals that have high impact on those steps; flame chemistry model for appraising further candidate chemicals; input for models of flame extinction; new families of candidate suppressants.

4d-2 IDENTIFICATION AND PROOF TESTING OF NEW TOTAL FLOODING AGENTS
Principal Investigator: Robert E. Tapscott, NMERI

Objective: Identify and develop performance data for best compounds from among the following classes: phosphorous nitrides, silanes, siloxanes. If a case can be made for fluorinated amines and/or ethers. then add them to the set.

Principal Deliverable: Determination of which types of these chemicals are the best candidates for further study.

4d-13. FLAME INHIBITION BY PHOSPHORUS-CONTAINING COMPOUNDS
Principal Investigator: Elizabeth M. Fisher, Cornell University
Associate Investigator: Frederick Gouldin, Cornell University

Objective: Identify and obtain performance data on the best of these chemicals, relations of which have been widely used in fire retardancy.

Principal Deliverable: Determination of whether and which types of phosphorus-containing chemicals are reasonable candidates for further study.

2.b. SUPPRESSION EFFECTIVENESS OF AEROSOLS AND PARTICLES
Principal Investigator: Ronald Sheinson, NRL
Associate Investigator: James Fleming, NRL

Objective: Obtain the data and understanding of in-flame aerosol behavior necessary to engineer improved heterogeneous agent dispersion systems with enhanced fire-extinction capability and to guide identification of candidate high-boiling liquids and particles.

Principal Deliverables: Diagnostics for in-flame characterization of fine aerosols and particles. Identification of their principal physical and chemical effects affecting the suppression process(es) within the flame.

4d-8. ELECTRICALLY CHARGED WATER MISTS FOR EXTINGUISHING FIRES
Principal Investigator: Charles H. Berman, AeroChem Research Laboratory

Objective: Determine whether charged water droplets are drawn to a fire and are more effective at suppressing it.

Principal Deliverable: Report on the effect (reduced mass and/or time) of charged water droplets on fire suppression.

4d-1. DEVELOPMENT OF A SELF ATOMIZING FORM OF WATER
Principal Investigator: Richard K. Lyon, EER, Inc.

Objective: Make mist systems consisting of molecular hydrates and determine whether they "explode" downstream, increasing the effectiveness of total flooding.

Principal Deliverable: Assessment of whether flashing of water can be effected by molecular hydrates and the approximate temperature range over which this is possible.

3.a. DISPERSED LIQUID AGENT FIRE SUPPRESSION SCREEN
Principal Investigator: Jiann C. Yang, NIST

Objective: Develop a bench-scale method for comparing the flame extinction performance of dispersed gases and liquids.

Principal Deliverable: Reliable bench-scale method for obtaining quantitative data on the effectiveness of candidate gaseous and liquid suppressants.

2.c. STABILIZATION OF FLAMES
Principal Investigator: Vincent Belovich, WL
Associate Investigators: W.M. Roquemore, WL; Sheldon Tieszen, SNL

Objective: Understand how and the extent to which flame stabilization can impact the observed effect of a suppressant and guide identification of technologies that mitigate this limit to suppression efficiency.

Principal Deliverables: Establishment of worst cases for extinguishment by gaseous, liquid and solid suppressants and the increases in agent concentrations needed to cause extinguishment.

3.c. LASER-BASED INSTRUMENTATION FOR REAL-TIME, IN-SITU MEASUREMENTS OF COMBUSTIBLE GASES, COMBUSTION BY-PRODUCTS, AND SUPPRESSANT CONCENTRATIONS
Principal investigator: Kevin McNesby, ARL
Associate Investigators: Paul C. Klara, Aberdeen Test Center and Andrzej Miziolek, **ARL**

Objective: Measure gas production and distribution during suppression of deflagrations in crew and engine compartments of a ground vehicle:

Principal Deliverahles: New instrumentation methods ready for use for all platforms of interest to the NGP.

## C. FY1998 New Start Solicitation

In January, 1997, proposals were solicited from both government laboratories for research in 16 Elements of the NGP and from non-government organizations in 7 of those Elements. The areas are:

1.b. ULLAGE INERTING IN-FLIGHT DATA COLLECTION

Objective: Obtain accurate data on in-flight ullage conditions on which to base a valid fire protection strategy.

Product: Assessment of proper fuel/air conditions needing protection based on accurate ullage fuel concentration data and other conditions in flight throughout the flight envelope.

1.c. RELATIVE BENEFIT ASSESSMENT OF FIRE PROTECTION SYSTEM CHANGES

Objective: Develop means to evaluate the relative desirability of potentially effective changes to fire protection systems and changes in fire suppression procedures that would enhance the efficiency of the suppression process.

Products: Methodology for assessing the impact each change in suppression system parameters has upon the effectiveness and cost of the entire weapons system.

2.a. MECHANISMS OF ULTRA-HIGH EFFICIENCY CHEMICAL SUPPRESSANTS

Objective: Determine how chemicals that are as or more efficient than halon 1301 quench flames characteristic of those identified in Thrust 1. This entails differentiating between chemical and physical effects, heterogeneous and homogeneous chemistry, etc.

Products: Identification of the most vulnerable steps in flame propagation chemistry; key properties of fluid, aerosol, or particulate chemicals that have high impact on those steps; flame chemistry model for appraising further candidate chemicals.

2.b. SUPPRESSION DYNAMICS OF FINE DROPLETS AND PARTICLES

Objective: Obtain the data and understanding required to engineer improved heterogeneous agent dispersion systems with enhanced fire-extinction capability.

Product: A validated model of the dominant suppression process(es) of small particles and aerosols.

2.d. EXPLOSION INHIBITION PROCESSES

Objective: Develop basis for "designing" explosion suppressants.

Products: A verified model of extinction of deflagrations; performance metrics for fast-flame quenchers.

## 3.a. SUPPRESSION SYSTEM EFFECTIVENESS SCREENING

Objective: Select, adapt, or develop test methods to obtain inexpensive fire suppression efficiency information on a diversity of suppression technologies.

Products: Techniques for estimating suppression technology performance; apparatus documentation for replication by other laboratories.

## 3.b. AGENT COMPATIBILITY WITH PEOPLE, MATERIALS AND THE ENVIRONMENT

Objective: Select, adapt, or develop test methods to obtain data on the toxicity, environmental impact, and materials compatibility of new suppressants and their principal degradation products during the tire extinguishment process.

Product: "Loose-leaf" handbook fully documenting methods for obtaining performance measures of the key properties of new agents and identifying the best temporary measures for those properties where there is no consensus method.

## 3.c. INSTRUMENTATION FOR GASEOUS FUELS, OXYGEN, AND SUPPRESSANT CONCENTRATION MEASUREMENTS DURING SUPPRESSION OF FLAMES AND EXPLOSIONS

Objective: Develop measurement methods needed for real-scale characterization of suppression performance and for determining combustion conditions in laboratory-scale apparatus.

Products: Instruments suitable for measuring fuellair ratios, agent concentrations, particle size distributions, number densities, composition. velocities, and radiant flux as a function of time and space in laboratory and, as needed, full-scale suppression experiments.

## 4.a. POWDER-MATRIX SYSTEMS

Objective: Investigate the concept of an agent dissolved in an inert polymeric or inorganic matrix with the specific property that it will be released rapidly at a temperature near or below the ignition point of the combustible mixture.

Product: New approach, with specific chemicals, for suppressing fires where cleanliness is not essential.

## 4.b. EVALUATION OF HIGHLY EFFECTIVE CHEMICAL SUPPRESSANTS

Objective: Identify and evaluate the full range of chemically active suppressants that are as or more effective than $CF_3Br$ and sufficiently low in toxicity and environmental impact.

Product: **A** list of promising chemically-active compounds with pertinent information on their physical and chemical properties, suppression efficiency, toxicity, storage stability, and breakdown products and their properties and toxicities.

## 4.c. SUPER-EFFECTIVE THERMAL SUPPRESSANTS

Objective: Determine whether there are practical physical suppressants of efficiency comparable to halon 1301.

Product: A list of promising compounds with pertinent information on their physical and chemical properties, suppression efficiency, toxicity, storage stability, and breakdown products and their properties and toxicities.

## 4.d. NEW AND MORE EFFECTIVE FIRE-SUPPRESSION TECHNOLOGIES THAT ARE PRESENTLY CONCEPTUAL

Objective: Introduce new and innovative approaches to fire suppression at the onset of the next-generation halon replacement program.

Product: New classes of high efficiency fire extinguishing agents and technologies

## 5.a. LIQUID MIST SYSTEMS

Objective: Improve small droplet suppression systems.

Products: Enhancements for mist suppression technology; new high efficiency fire extinguishing agents.

## 5.d. ADVANCED PROPELLANT/ADDITIVE DEVELOPMENT FOR GAS GENERATORS

Objective: Develop new types of chemically-generated gaseous suppressants

Products: New solid propellant gas generators and an understanding of the fundamentals of their behavior.

6.b. SUPPRESSANT FLOW THROUGH PIPING

Objective: fluids with widely varying physical properties and flow conditions.

Products: A validated, available computer code for calculating single- and two-phase flow in pipes for fluids of diverse physical properties. Laboratory data on flows, pressure losses, friction coefficients, Reynolds numbers, etc., for water and other suppression system fluids in pipes under the needed range of pressures and flow velocities.

6.c. MECHANISM OF UNWANTED ACCELERATED BURNING

Objective: Characterization of the mechanisms responsible for the enhanced burning which is sometimes observed when fire extinguishing agents are first applied to flames.

Products: Tabulation of test conditions to be replicated (if accelerated burning is a concern for that type of fire) and real-scale conditions to be avoided.

**79** proposals have been received and subjected to peer review. The programmatic review process is underway, with decisions expected in mid-September, 1997.

## D. FY1999 Solicitation Plan

**A** solicitation for proposals to a smaller set of project areas is expected to be issued in December, 1997. Proposals will likely be due in March, 1998. At present, it is expected that the announcement will appear at the SERDP web site (www.hgl.com/SERDP) and in *Commerce Business Daily*.