TITLE OF SUBMISSION: ENHANCED DEGRADATION OF MILITARY MATERIEL

PROPOSED CONCEPT, CAPABILITY AND TECHNOLOGY INVESTMENT:

The proposed materials science research project will develop non-lethal systems specifically designed to degrade opposing forces' mobility, logistical support and equipment maintenance programs prior to or during military engagements, in a time frame of days to months. Such systems, patterned after microorganisms and their products, as well as "vaccinations" to protect materiel of friendly forces, will be directed exclusively at non-living targets such as highway and runway surfaces, metal parts and coatings of weapons, support equipment and vehicles, fuels and other supplies and replacement parts. Natural environmental microorganisms displaying relevant degradative capabilities will be identified, and their mechanisms(s) of degradation will be characterized. In addition, non-pathogenic laboratory strains will be genetically modified to express specific, focused degradative capabilities. These Genetically Modified Microorganisms (GEM) will be further modified to be self-limiting, either by incorporation of timed "suicide" genes, or other alterations that prevent their persistence in the environment beyond pre-determined limits of space or time. Ultimately these capabilities will be mimicked chemically, and transitioned into synthetic products that do not require living microorganisms. At the same time, chemical, physical and engineering modifications that can be applied to materiel of friendly forces to "vaccinate" and protect such targets will be investigated.

The proposed microbial-derived systems will be used to accelerate the corrosion, degradation or decomposition of roads and aircraft runways used by opposing forces. In addition, targeted deterioration of metal parts, coatings and lubricants of weapons, vehicles and support equipment, as well as fuels and other supplies, will significantly increase the cost and logistical burden to the enemy of sustaining military operations. An important focus area addressed by this proposal includes denial of land areas to vehicles and aircraft by reduction of terrain trafficability and vehicle operation. Another focus area is the ability to disable or neutralize equipment and facilities, by degrading fuels and other supplies, and increasing maintenance requirements.

POTENTIAL FOR JOINT APPLICATION:

All of the armed services in a joint military operation will benefit from technology that degrades the overall ability of the enemy to initiate and sustain combat operations. Degrading aircraft runway surfaces controlled by enemy forces gives an advantage to U.S. Air Forces in controlling the skies over target areas. Degrading road and highway surfaces in enemy territory reduces the mobility of opposition forces' troop and supply transport, reducing the threat to Army and Marine land forces. Degrading fuels, replacement parts and other supplies that support a war effort gives an advantage to all branches of our military by compromising the enemy's logistical support systems.

In addition, characterization of degradative mechanisms and development of "vaccination" strategies will have significant dual use applications in protecting military and commercial materials and material from naturally-occurring biodegradation problems, or offensive military and terrorist attacks of this nature. Scientific expertise capable of developing anti-material technology patterned after microbial systems unquestionably is already present in the laboratories of potential adversary states, and the likelihood of near-term development of such threats is great. Failure to

counter this threat with a focused research program jeopardizes the warfighting capability of the U.S. and its allies.

TECHNICAL DESCRIPTION:

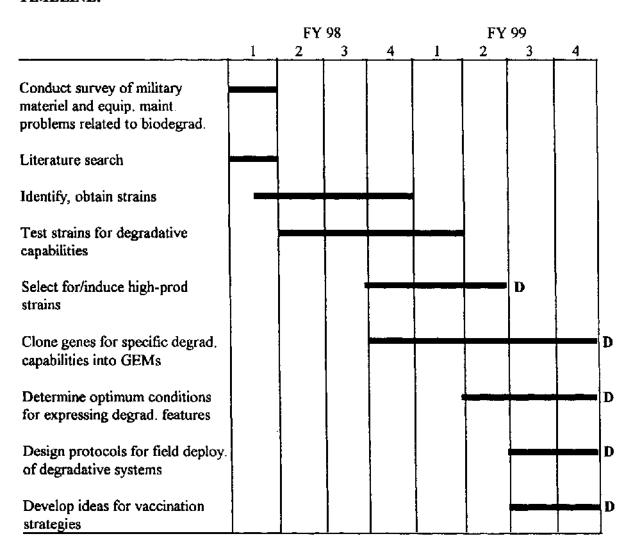
Nature has provided many examples of natural degradation by microorganisms of metals (1-4), fuels (5,6) and a variety of synthetic products (7,8), as well as structures and systems that incorporate or depend on such products. An example of a military material that the proposed research would target is the synthetic high-strength polymer, Kevlar, or novel biomimetics of Kevlar based on spider silk. Asphalt is degraded by several strains of bacteria, leading to greatly reduced road surface lifetimes (9). Components of asphalt used for other construction purposes also suffer failure as a direct result of bacterial degradation (10). Cement is subject to rapid, component-specific attack by microbes (11). Most classes of paints and coatings are also vulnerable to degradation by microbial products (12-14). Virtually all petroleum, oil and lubricants (POL) of military relevance are vulnerable to degradation by microbial action (5). Many microorganisms also naturally produce minute granules called inclusion bodies that are made of salt crystals, metals or plastic-like compounds (polyhydroxyalkanates). These particles will quickly clog high efficiency filters, and convert critical lubricants of weapon systems into gums or abrasives. It is the purpose of the proposed research to capitalize on the degradative potential of these and other products from naturally-occurring microorganisms, and to engineer additional, focused degradative capabilities into GEM, to produce systems that will degrade the warfighting capabilities of potential adversaries. The out-years goal is to use the knowledge of natural microbial degradation pathways gained in this study to develop biomimetic chemical systems that are more robust, less expensive and easily deployed for field use in any warfighting environment. The genetic engineering techniques to be employed are standard laboratory practices, requiring no special isolation laboratories, and this proposed materials science research is not restricted in any way by the 1972 Geneva Convention on Biological Warfare or any other international agreement. Funding for this proposal will support scientific staff who will develop enhanced materiel-degrading technology for deployment to the field. Previous work by the P.I. (JRC) at the Naval Research Laboratory (NRL) identified and produced in the laboratory an enzyme from a naturally occurring fungus, which rapidly decomposes polyurethane, a common component of paint for ships and aircraft (15). This work was subsequently extended at NRL, to create a new GEM that overproduces the polyurethane degrading enzyme (U.S. Patent, Navy Case No.75461) (16).

RISK AREAS:

The main risk area for this technology lies in the engineering of the GEM to produce or enhance the desired characteristics, and in the robustness of these strains for field deployment. In the hands of skilled molecular biologists these risks will be minimized, because a large selection of DNA vectors and host organisms already exists for engineering purposes, and the literature documents numerous successful techniques for designing and producing stable GEM. NRL and its scientists have an established track record in molecular biology, protein characterization and surface chemistry. Field robustness is a concern, because of the wide variety of environmental conditions that could be encountered by the microbial products when employed in different

warfighting scenarios. However host microbes are available that grow readily, and synthesize degradative products that function well, under a range of conditions of temperature, pH, salinity and humidity, and NRL Code 6115 employs several microbial ecologists trained and experienced on these issues. Moreover, it is not the intention of this research to develop strains that will persist in the environment once they have delivered their effects to the target. On the contrary, microbial systems will be identified or engineered to produce the desired degradative effects within a matter of days to months, then die off and disappear. This technology will then be transitioned to chemically synthesized systems to improve and extend the desired characteristics.

TIMELINE:



D = deliverable

COST:

Personnel:

Personner:	FY98	FY99
Ph.D., CAPT, MSC, USN (25%)	0K	οK
Ph.D., LT, MSC, USN (25%)	0 K	0 K
Ph.D. (25%)	30 K	31.5K
Technician (100%)	90K	94.5K
Supplies:		
DNA cloning, sequencing supplies	20K	20K
Computer, molecular biology software	5K	0 K
Survey costs (travel, data processing):	5K	0 K
TOTAL	150K	146K

DELIVERABLES:

- 1. Bacterial and fungal strains or their purified products, with the ability to:
 - a. Degrade components of asphalt, cement or other road surfaces,
 - b. Decompose or compromise quality of POL,
 - c. Degrade paints, coatings and lubricants used for military hardware or vehicles,
 - d. Initiate or accelerate corrosion of metal surfaces.
 - * Prioritization of development of specific degradative characteristics will be determined In discussions with sponsors.
- 2. Target-specific GEMs, and optimum conditions for growth.
- 2. Recommendations on feasible delivery systems for the products.
- Recommendations on procedures for "vaccinating" materials and material of friendly
 forces to protect them against inadvertent exposure or military/terrorist attacks with the
 products.

TECHNICAL POC:

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