(White Paper)

Title: Prototype Development of an Assignment System for Drone/ Amazon Deliveries

1.0 Introduction

The delivery of packages by the use of drones is soon to become a reality. Amazon.com, Inc. has designed a drone to make deliveries (Exhibit 1) and has appealed to the Federal Aviation Agency for permission to commence with flights. Once operations are intact, economic improvements become necessary. Instead of a single destination for the delivery of one package, several packages can be loaded per drone. By doing so, the cost of the system is reduced dramatically. But, multiple delivery sites per drone introduces a greater level of complexity.

As a solution, NBS Enterprises (NBS) has developed a software tool suite that matches drones and destinations optimally within the context of a multi-drop mission. Once data are structured for input to the tool suite, assignment calculations are computed in near real-time rather than hours of human think time. In addition, optimal selection of package supplies and locations for embarkation are optimized, as well as the optimal loading of multiple packages. Further, applications of the algorithms negate the probability of collisions between drones and other types of aircraft during the delivery phase.

The NBS algorithms exist, have been tested and scale up so that only an integration of data with the tool suite is required for applications.

The purpose of the system described in this paper is not to address the issues of physical control of drones, but rather to assist with the management of delivery routes within an extensive and dynamic drone environment.

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Exhibit 1

2.0 Air Tasking Orders

An air tasking order comprises three functions: a) planning, 2) execution, and 3) debriefing.

Typically, for the simultaneous flight of multiple drones loaded with multiple packages, several hours are spent during the planning stage whereby areas of interest are defined as well as required resources. Analysts must decide first if the mission can be supported and thereafter locate and synthesize resources and finally allocate drones to multiple targets. During the execution phase, near real-time decisions are necessary to respond to a dynamic and changing delivery structure, revised mission objectives, and the failure of aircraft.

3.0 Core Capability and Technology

A new operational concept, more demanding operating environments, and more diverse operational schemes combine to present a delivery director with ever more complex decisions.

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NBS has developed a prototype Decision Support System (DSS) and will subsequently transition the DSS into a field-able, web-based system that supports course of action (COA) analysis and assists with optimal assignments of drones in the face of a dynamic environment. The DSS allows a director to:

1. Define a mission and automatically generate the associated deployment requirements
2. Receive and implement logistics and operational control parameters (e.g. prescribed loads, operating hours, environment, etc.)
3. Automatically locate the equipment/resources required to fulfill the mission and optimize their selection and collective point of debarkation
4. Merge several optimized courses of action into a single course of action that leverages synergistic relationships
5. Optimize loading, routes and transportation methods
6. Perform interactive contingency analysis in response to "what-if" scenarios
7. React rapidly to changing circumstances to modify resource allocation decisions and prevent collisions
8. Generate reports detailing the selected course of action, as well as those courses of action that have been assessed and saved for back up possibilities

4.0 Implementation Algorithms

NBS implementation algorithms comprise a suite of four intelligent agents:

a. A **Composition Agent** that searches the networked data marts to locate required resources and then optimizes their selection and collective point of debarkation.
b. A **Merging Agent** that rapidly considers thousands of synergistic loading distribution combinations, either within or across missions, to minimize the required transportation footprint.
c. A **Route Planning Agent** that determines optimum routes for deployment while considering time, obstacles, and other specified constraints both in the planning and execution phases of deliveries.
d. A **Contingency Planning Agent** that rapidly models and assesses the impact of user-defined contingencies or "what-if" scenarios on a given course of action and recommends efficient reconfigurations.

The search and optimization/analysis needs of the COA planners are serviced by an innovative calculation, which has been demonstrated during several studies and analysis projects. This engine uses Petri-Net algorithms and a state-of-the-art, multi-stage dynamic programming algorithms to generate near-instantaneous solutions to large-scale assignment deliveries.

5.0 Multi-Level Optimization

The NBS decision support system, as noted in Exhibit 2, comprises five tiers of optimization:

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a) Package contents are selected from several choices
b) The synthesis location for packages and drones is chosen optimally
c) The loading of packages onto drones is conducted in response to constraints such as weight, size, and center of gravity. In addition, queuing profiles such as last on-first out are structured. The packages are also loaded to assist with the minimization of distance traveled by the drone suite.
d) Assignments of drones to delivery locations are optimized such that distance traveled is reduced relative to package and environmental constraints.
e) Any unforeseen events during delivery are responded to so that mission objectives are sustained and collisions are avoided.

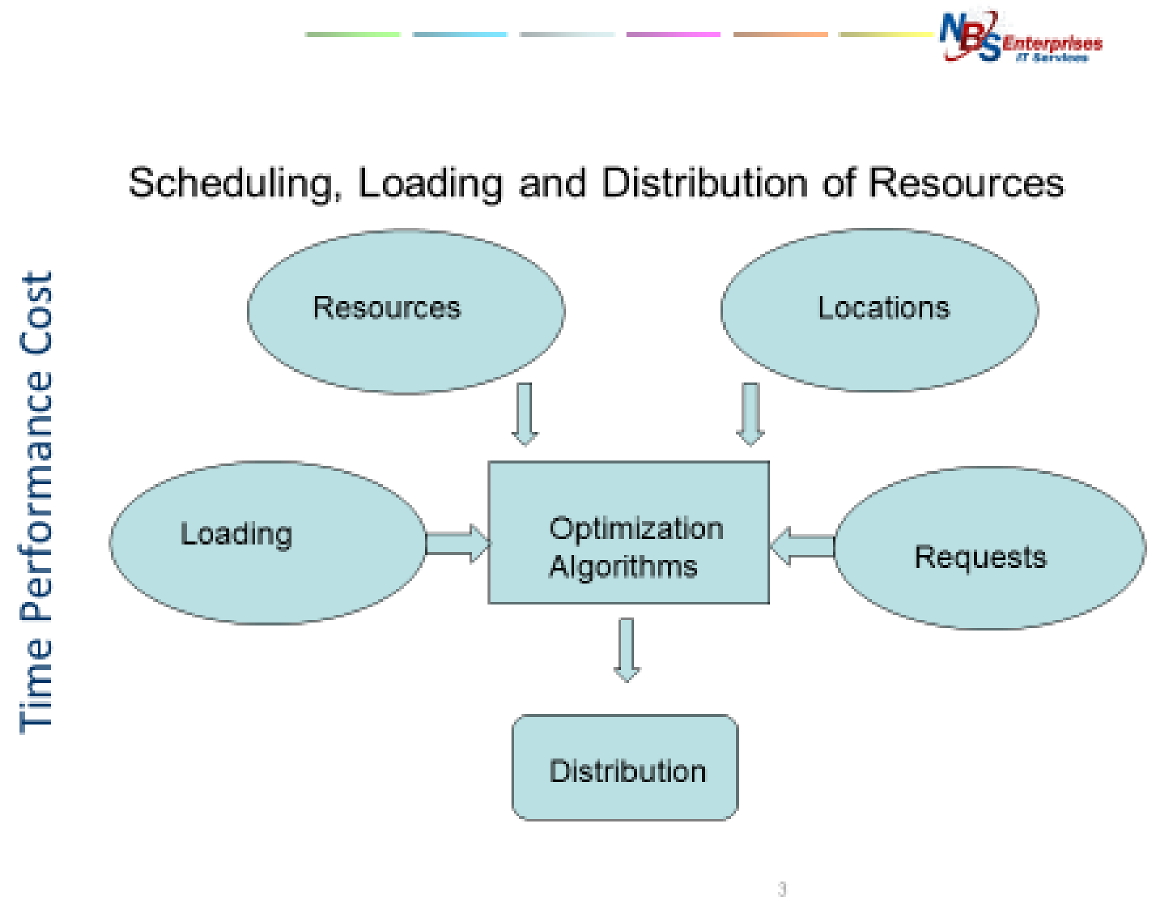

Exhibit 2

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6.0 Benefits

The NBS decision support system provides enhancements primarily during the planning and execution phase of an assignment mission.

a) Optimal loading of packages
b) Optimal routing of drones during the planning stage
c) What if and contingency analysis
d) Reconfiguration of the mission and reassignment of aircraft in near real-time during the execution phase
e) Deconfliction of drones and commercial aircraft preventing collisions.
f) Dramatic cost reduction due to multiple package loads

Although data acquisition might still be time consuming, the planning of optimal assignments is reduced to minutes from hours of think time. During execution, reassignments of drones is computed almost instantly.

7.0 Feasibility

Based upon experience with other applications, the tool suite development is entirely feasible

8.0 Risks

The assignment algorithms are fully developed and have been applied to commercial assignment and distribution problems. Military applications are also extensive. Absolutely no risk other than data access is foreseen for mission applications.

9.0 Bio Material

Gary S. Schebella

Gary S. Schebella is the chief scientist for NBS Enterprises. He has participated in the management, analysis and development of several commercial and military systems. He has addressed the operations of large-scale information networks. He has directed research teams, simulated and modeled enterprises in order to compute performance, to derive requirements and to assist with the transition of 'as-is' to 'to-be' system architectures. He has developed optimal flow algorithms for communications systems as well as dynamic sensor and communications node reconfigurations. He has created innovative techniques in business process reengineering and analytic decision support for course of action computations and analytical forecasting. He once acted as the primary analyst for the honorable Paul Nitze during the strategic arms

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limitations talks with the Soviet Union. While an air force officer in Southeast Asia, he developed and assessed interdiction schemes for sensors located on the Ho Chi Minh trail. He also was the project officer for a 3000-pound laser guided bomb used to destroy bridges between North Viet Nam and China.

His methods provide guidance for the system design and development process and help to ensure performance prior to implementation. They also provide near real-time course of action evaluations during system operations.

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Appendix A: Corporate Background

NBS Philosophy and Expertise

Political and positional success is directly tied to leadership's ability to lead their organizations, to identify and capture 'at hand' efficiencies, make sound/pragmatic resources optimization decisions, and then continually drive tangible 'continuous process improvements'. Both novel and noble objectives, which are absolutely essential in today's economic reality.

NBS Enterprises has the right Enterprise Resource Optimization (ERO) model and enabling algorithmic toolkit to empower senior executives with the insight necessary to identify and execute the best course of action for their organization. The NBS tool suite is known as Time-Lives-Cost (TLC). We are ready to help senior executives who are addressing a mandate to capture cost savings and efficiencies across their operations.

History

NBS Enterprises (NBS) is a woman owned small business founded in 2005 by Natasha Schebella.. We have capabilities and experience in three major areas: 1) Decision Support, 2) Information Technology (IT) Solutions and Services and 3) Staffing Services. NBS has personnel that routinely deliver in adverse environments both in the US and abroad, all focused on serving the same mission: the advancement and security of the United States.

NBS possesses exceptional talent in the management and technical administration of global requirements for the Department of Defense and numerous commercial businesses. The experience that NBS has gained through programs with customers include the Defense Threat Reduction Agency (DTRA), the Office of Naval Research (ONR), the Department of State and the Diplomatic Telecommunications Service – Program Office (DTS-PO), and the Washington Metro Transportation Services, which enables us to skillfully and efficiently coordinate and execute complex planning and decision support.

Decision Support

NBS has developed logistics decision support algorithms for the Marine Corps, Navy and the Coast Guard. We have also developed optimal assignment for Hospice organizations, matching personnel and resources with patient requests. Based upon our understanding of logistics distribution and the routing of transportation vehicles , we have developed a full compendium of algorithms that provide courses of action for management, communications systems, and the design of sensor exploitation systems. We have also conducted studies and analysis of weapons of mass destruction and have devised exploitation systems that assist in the denial of terrorist threats.

IT Solutions and Services

NBS has been serving the Intelligence, DoD and Civilian Communities for 9 years. We have successfully delivered solutions in the areas of Information Assurance (IA), Enterprise Architecture, IT Transformation and Modernization, ITIL, Risk Management, Data Center transformation modernization, Security Assessments and Design, cloud environments, Human Resources, and Logistics and Mission

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support. We specialize in delivering exceptional results on projects with our trained, certified and cleared staff in the most widely used technologies.

Staffing Services

NBS provides direct staffing, temporary to permanent staffing, and temporary staffing in the intelligence, DoD and civilian communities, specializing in information technology and information assurance. The personnel include individuals with top-level clearances and experience. NBS also provides skilled individuals for accounting and financial services, as wells as program and administrative support. We have a reputation for responding rapidly to meet our customer needs.

Appendix B: Calculation Engine

All merging, route planning, and contingency planning agents of the proposed DSS use a common, well tested calculation engine. The calculation engine acquires the proper set of computational algorithms and synchronizes appropriate input data.

The NBS paradigm employs one network representation to permit both performance computations and learning. A Petri net is, in essence, a rule-based representation of a network or any arbitrarily complex system. By associating time with the instantiation of rules/events, the network becomes stochastic and can be transformed to a Markov chain. The Markov matrix is solved using sparse matrix technology or simulation producing typical performance statistics such as throughput, utilization, response time, and queue length for each node/event in a network. A neural net with input, internal, and output nodes is useful for learning purposes. In the context of the representation scheme, back propagation is employed whereby outputs computed by the Petri net, are compared with requirements and, if unequal, routing probabilities of the net are changed incrementally with weight functions. When applying the toolkit, performance is propagated forward and learning is back propagated. Only one network representation is necessary. Input nodes insert work and data flow into a network; internal nodes are used for processing and distribution; and output nodes provide the delivery of a resource to a customer. The paradigm encompasses the definition of a distributed network, input attributes, transport attributes, and output requirements. In addition, probabilistic events such as survival or the propagation of belief can be represented. The performance model is solved after inserting random or best guesses for a distribution scheme. Thereafter, back propagation takes place to improve the distributed solution.

Optimization and variable balancing are always accomplished in the context of a systems model. Mission scenarios, system architectures, and functional requirements are represented with objects and attributes. The objects and attributes are transitioned to a rule-based system and further to an analytical model. The model is exercised with the purpose of maximizing an objective function such as targets killed in an air defense mission or supplies delivered in a logistics scenario. The results of a computation are compared to desired data or requirements and, if not satisfactory, back propagation is implemented to change the traffic flow through a network or the processing rates at particular nodes. Variables are perturbed, subject to constraints, until a result is maximized or at least satisfactory. Only one measure of system effectiveness can, of course, be optimized while all system variables are balanced to best achieve an objective. The variables

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represent competing measures of performance such as minimum delivery time of a resource versus minimum destruction probability of the delivery platform. The combined performance/learning capability permits an analyst to experiment with a solution without searching for bottlenecks. The network evolves as it searches for an acceptable solution.

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