MODERN TECHNOLOGY SOLUTIONS, INC.		4725B Eisenhower Avenue Alexandria, Virginia 22304
www.mtsi-va.com		Phone: 703-212-8870 Fax: 703-212-8874

31 May 2007

Ms. Diane Blair, Coordinator
Base Realignment Impact Committee (BRIC)
Grand Forks Region Economic Development Corporation
600 DeMers Avenue, Suite 501
Grand Forks, ND 58203

Subject: Grand Forks Unmanned Aviation Business Development Roadmap, Deliverable 4, Final Copy, dated 31 May 2007.

As the Prime Contractor for the subject Roadmap, Modern Technology Solutions, Inc., (MTSI) is pleased to submit the final copy of all deliverables from the MTSI-CEO Praxis Team's Grand Forks Unmanned Aviation Business Development Roadmap. This submittal contains all tasks as required by this date, in final form. In addition, it provides a Microsoft Project work plan for implementing the Roadmap's recommendations.

Should you have any questions or need additional information, please contact
Mr. Mark Micieli at 703-212-8870 x121 or 703-587-8418 (c).

Sincerely,

Philip L. Soucy
Co-President, MTSI

Enclosures:
Grand Forks Unmanned Aviation Business Development Roadmap (Final Copy), dated 31 May 2007

Executive Summary

Unmanned aviation dawned on the Grand Forks horizon when the Defense Department's 2005 Base Closure and Realignment Commission (BRAC) announced Grand Forks Air Force Base, with its 3000 employees, was on its list. The region immediately set to work along two vectors, to reverse the BRAC decision and to identify and attract new businesses to compensate for the loss of the base if unsuccessful. For the former, they were partially successful in that the departure of the manned aircraft was somewhat offset by plans to base unmanned aircraft at the base that would be controlled from Hector Air National Guard Base in Fargo. This outcome resulted in unmanned aviation being adopted as one of four new growth industries for Grand Forks to pursue in addressing the new businesses vector. This Roadmap documents the initial game plan for how Grand Forks can take a leading role in this emerging industry.

In two short years, and with strong Congressional and State support, Grand Forks has hosted two national-level conferences ("Action Summits") on unmanned aircraft systems (UASs), established a UAS Center of Excellence at its University of North Dakota, and obtained funding from the federal Office of Economic Adjustment to map out its future in the unmanned aviation market. In addition, both the Department of Homeland Security's Customs and Border Protection office and the U.S. Air Force have announced plans to base UAS units at Grand Forks AFB, complementing the ANG unit. By 2012, over 20 large UASs should be operating on a regular basis over the region. How this presence can be leveraged to bring additional unmanned aviation industries, business, and careers to the region is the subject of this Roadmap.

The Roadmap begins with an overview of the current unmanned aviation market from a U.S. and a worldwide perspective, describes the major challenges facing it, and the likely timeline for their resolution. The major challenge is gaining routine access to airspace in which UASs are authorized by the Federal Aviation Administration to fly; this issue is not expected to be resolved until 2012-2015. It next takes inventory of the region's attributes and infrastructure for attracting unmanned aviation business, using a cluster approach for describing these assets. From the cluster approach, it identifies the shortfalls in the region's infrastructure and suggests ways to overcome them. The major immediate shortfall is seen as the lack of restricted airspace in which to launch, fly, and recover UASs within the region and specifically from Grand Forks AFB.

Grand Forks is not alone in its pursuit of unmanned aviation business, with some of its competitors having been engaged in this market for most of the past decade. The next section describes these competitors and gives a frank ranking of Grand Forks versus them. The Roadmap then provides a long term assessment of the prospects for the unmanned aviation market and how it will likely unfold over the coming decades. Three out of every eight flights under instrument flight rules are forecast to be unmanned by 2050.

The final section focuses on the core issue of this Roadmap, the identification of attainable near and long term business opportunities in unmanned aviation. Near term ones are those that can be exploited in the current airspace regulatory environment, and long term ones are those that must wait for FAA action to create a "file and fly" regulatory environment for UASs, where unmanned and manned aircraft have equal access to the National Airspace System. Thirty-one opportunities are described, ranging from dipping UAS engine parts in Technology Applications Group's tagnite solution to helping train future Army and Navy UAS pilots at the University of North Dakota and improving crop yields with imagery from unmanned aircraft. It concludes with a MicroSoft Project chart showing the timing of events needed to make Grand Forks a regional, then a national leader in unmanned aviation.

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INTRODUCTION

Purpose. To characterize the existing Grand Forks, North Dakota, infrastructure for supporting unmanned aviation, identify potential market opportunities for unmanned aviation in the Grand Forksregion, and to offer recommendations on how to capitalize on those opportunities, to the Base Realignment Impact Committee, a partnership of Grand Forks County, City of Grand Forks, and Grand Forks Region Economic Development Corporation.

Scope. The scope of this 4-month effort is to develop a comprehensive and strategic *Unmanned Aviation Business Development Roadmap (UABDR)* for the Grand Forks Region.

The market examined in this study will consist of potential customers (military, civil, and commercial), and the required infrastructure for developing unmanned aviation business in North Dakota.

Definitions. The term Unmanned Aircraft System (UAS) refers to the entire composite system which includes the aircraft, payloads, the control station, the command, control and communication links, and trained personnel to operate it.

1.0 UNMANNED AVIATION INDUSTRY OVERVIEW

The following questions recur frequently (in various forms) at unmanned aviation conferences, and the answers provided below represent an amalgamation of inputs from those manufacturers and government officials responding to them, as well as from official documents and briefing materials.

1.1 *What is the current size of the worldwide and U.S. unmanned aviation markets?*

An estimate can be made by extrapolating the Fiscal Year 07 President's Budget for Department of Defense unmanned aircraft systems to the worldwide market. DoD, the world's largest customer for UASs, plans to spend $12.2 billion over the 2007-2011 5-year period on UAS research, development, test & evaluation (23.3%), procurement (62.6%), and operations & maintenance (14.1%). This is an average of $2.4B per year, with a 46 percent growth occurring between FY07 ($1.8B) and FY11 ($2.6B), almost all of it in the procurement sector (some 200 percent). RDT&E and O&M expenditures, after factoring in inflation, are essentially flat over this period. (Source: OSD Unmanned Systems Roadmap, 2007 draft)

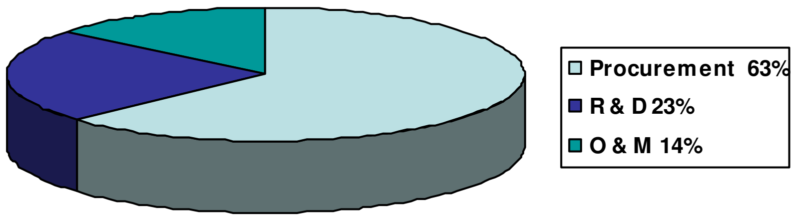


Figure 1-1. 2007-2011 DoD UAS budget.

Within the U.S., the Department of Homeland Security is the second largest UAS customer, spending about 3 percent of what DoD does each year on UASs. Adding all other U.S. spending on UASs, government and commercial, to what DHS spends would total at most 10 percent of what DoD spends, so total U.S. spending over the 2007-2011 period is expected to be $13.4B, or an average of $2.7B annually.

Worldwide, 50 countries operate UASs, although only 22 manufacture them. The U.S. is currently estimated to compose 55 percent of the worldwide UAS market. By extrapolation, this makes the worldwide market for unmanned aviation over the FY2007-2011 5-year period some $24.4B, an average of $4.9B per year.

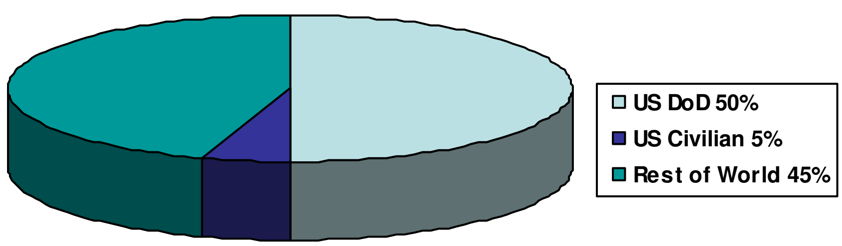


Figure 1-2. Current worldwide UAS market.

The largest contributor to this growth is the DoD's procurement of UASs, and the dominant assumption is that the main driver for this procurement, military operations in Iraq and Afghanistan, continues throughout this period. If the U.S. military redeploys from Iraq in the near term, this could reduce UAS procurement spending, which in turn could reduce the above U.S. and worldwide UAS market estimates.

The U.S. unmanned aviation industry today consists of 85 companies located in 33 states (North Dakota not among them) and a roughly equal number of component suppliers. Of these 85, 58 are very small businesses (less than 20 employees), and 62 produce no other products except unmanned aircraft. Nine of the remaining companies are large aerospace corporations whose unmanned aviation segments account for less than 1 percent of their combined revenues of $143 billion. (See Figure 1-4.)

1.2 *What are the likely dynamics of this market over the next decade?*

The "dynamics" of the unmanned aviation market will depend greatly on what airspace policies are implemented by the various nations using them. Within the U.S., current airspace policies allow UASs to fly by one of three avenues, a certificate of authorization or COA (public UASs only), a special airworthiness certificate for experimental purposes or SAC (civil or public UASs), or by remaining within special use airspace or SUA (public/military-sponsor only). This situation is not expected to change over the next 5 years, due, among other issues, to the lack of an accepted solution for automating see and avoid provisions aboard UASs.

The FAA forecasts requests for COAs will grow from 54 in 2005 and 107 in 2006 to 428 in 2010. It anticipates SAC requests will grow from 5 in 2005-06 to 42 in 2010 and 59 by 2011. Together, these rates predict a 900 percent expansion in UAS flight activity in airspace shared with manned aircraft by 5 years from now.
The second half of the next decade will likely see a resolution of the see and avoid issue as well as, hopefully, the others, making this a transition period as far as "market dynamics" are concerned. This transition period will see the start of routine flights by UASs in non-segregated airspace along our borders, off our coasts, above airline/business jet altitudes (50,000+ ft), and at very low altitudes (under 1000 ft). Routine, or "file and fly," operations will eventually offer a fourth avenue for UAS access to the National Airspace System, although some UASs will need to continue to use the COA or SAC process.

1.3 *What segments of this market will see the largest growth?*

If segments are defined on a customer basis, the U.S. military, with a projected UAS investment growth of some $800 million (46 percent from a starting point of $1.8B) over the coming 5 years, will see the largest growth, with the civil government segment (DHS, NASA, NOAA, et al) second. The commercial segment however will likely overtake the civil government segment in the latter half of the coming decade.

If segments are defined by category of UAS, the small UAS class will probably see the largest growth, certainly in numbers, if not in value (one Predator B aircraft costs the equivalent of 740 Cropcam aircraft). It will likely be the dominant UAS class of choice for the anticipated expansion in the commercial segment.

1.4 *What will be the regional trends in research and production?*

The most likely trend in unmanned aviation research over the coming decade will be in developing automated collision avoidance systems. Today, those companies leading in this research are scattered across the country, in the Boston, Washington, Dayton, Dallas, Minneapolis, Cedar Rapids, and Los Angeles areas.

With some 85 companies in 33 states, UAS production is currently in an over-supply, under-demand status, although many of these 'companies' are essentially incorporated RC model hobbyists. The two maps below (Figures 1-3 and 1-4) contrast the manned versus the unmanned aircraft production situation. From the unmanned map, it is apparent that these 85 companies are located in every U.S. region except the Northern Plains and Rocky Mountain regions. Once airworthiness standards for UAS production are established by the FAA, probably in the latter half of the coming decade, many of these companies will revert to being hobbyists and some consolidation will take place among the larger ones.

One demonstrated trend is the relocation of UAS production facilities to regions of lower labor costs. Examples include Northrop Grumman locating its Fire Scout and Global Hawk fuselage production to Moss Point, MS, and Aurora its Hunter line to Starkville, MS.

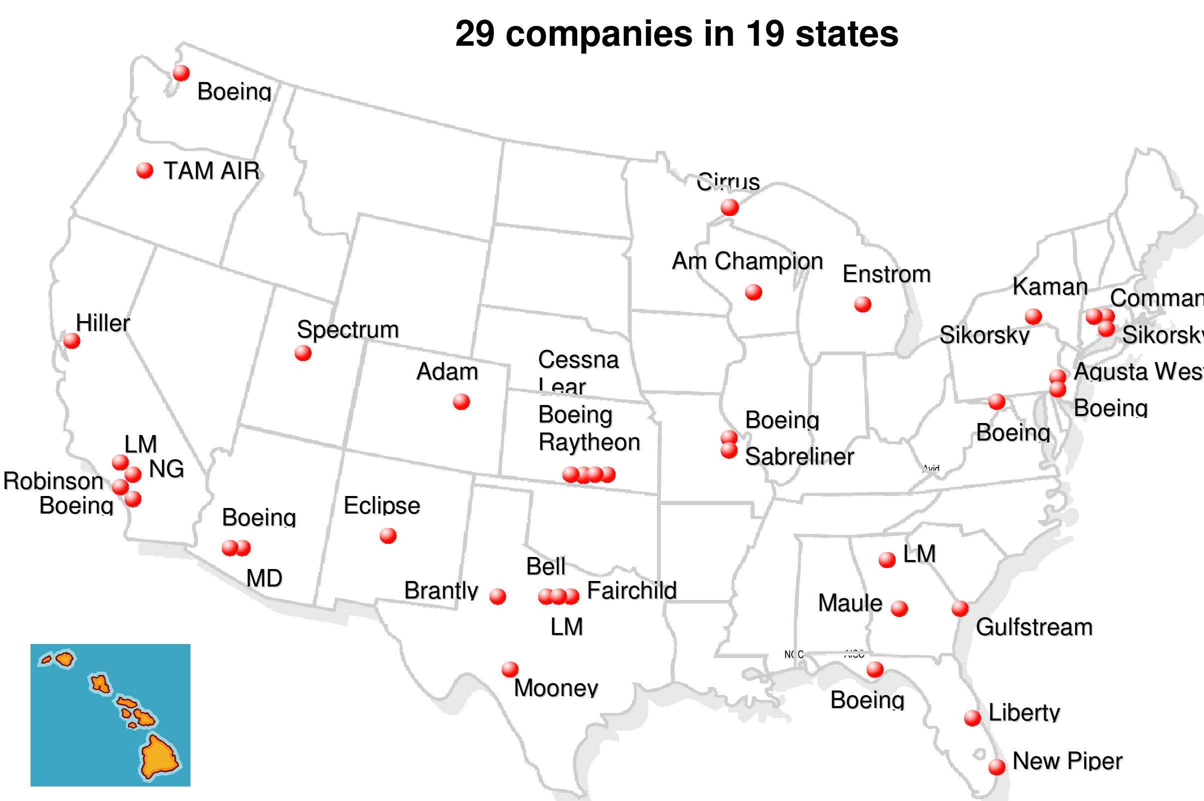


Figure 1-3. Manned aircraft industry.

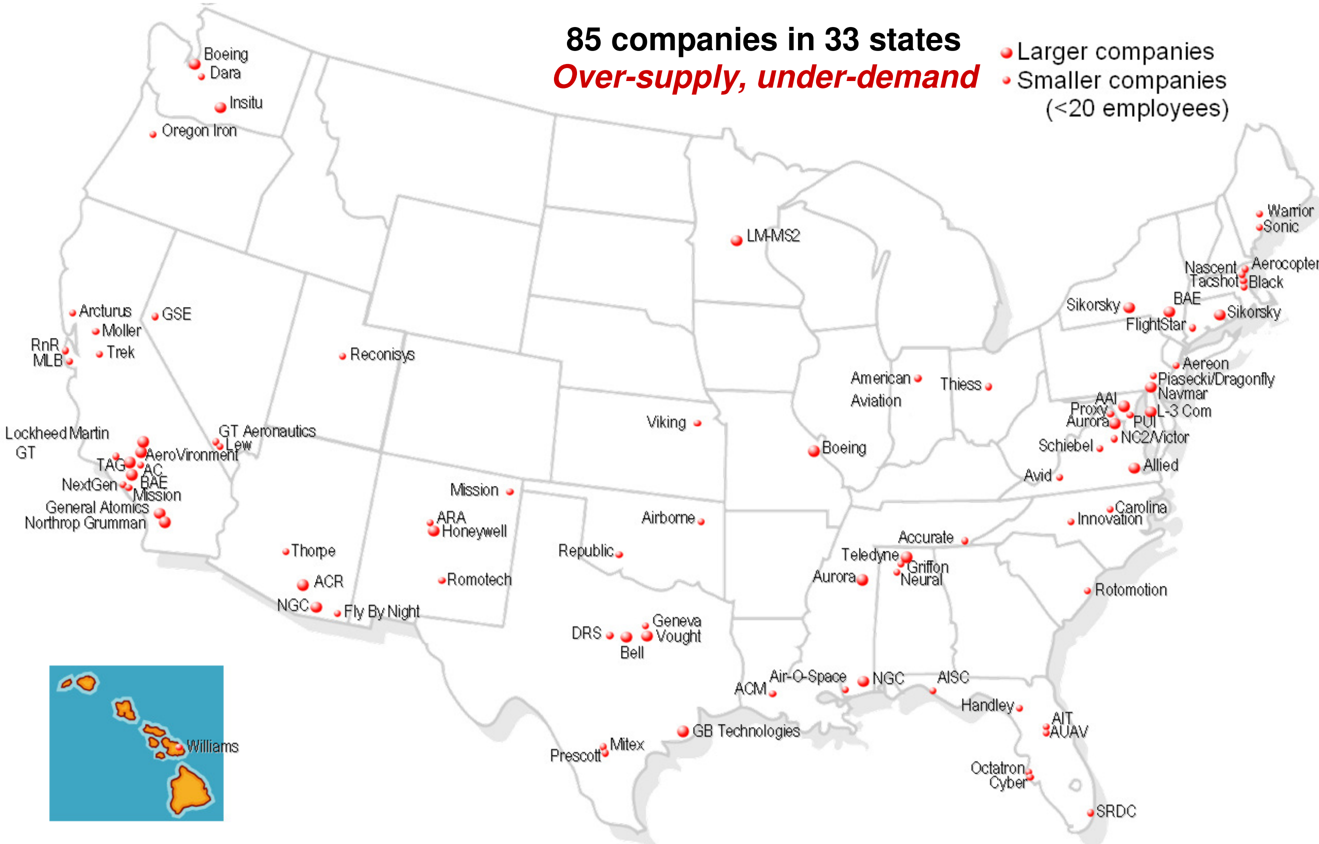


Figure 1-4. Unmanned aircraft industry.

1.5 *Is a civilian market likely to emerge over the next decade?*

A small but sustained civilian market for UAS services has already emerged.

In Japan, some 2000 remotely piloted helicopters (RPHs) are employed in the agriculture industry to plow, fertilize, and apply pesticides to 10 percent of their rice crops. This service began in 1990. Four RPH manufacturers support this market, with Yamaha being the dominant one. Their regulation is handled under the ministry of agriculture rather than that of aviation. Yamaha also leases its RPH services to the city of Tucson for urban insecticide spraying.

In the U.S., Coptervision manufactures and operates RPHs for the film industry, using them to film high speed case scenes, hangar fly-throughs, and other hazardous shots. Aerosonde, an Australian-U.S. company (now part of AAI), regularly leases its services to the Air Force, NOAA, and the National Science Foundation for weather monitoring and climate studies. Both have been in business since the late 1990s.

Agriculture is the dominant civilian market in the Grand Forks region, and indigenous unmanned aviation companies are now emerging to support it. The precision agriculture market has seen several UAS service providers begin operations outside of Japan in the last 2 years, such as Cropcam of Manitoba, Calmar of Indiana, and AeroView of Maryland.

The FAA currently allows 'private' UAS owners to operate their UASs only under a SAC and without compensation, meaning service providers must sell their systems to the customer. Obtaining a SAC typically takes 4 to 6 months and requires a detailed safety analysis of the aircraft and the planned operation to be submitted. The FAA's UAS Roadmap, due to be released in Sep 07, is to make recommendations for certifying small UASs, which could lead to a separate, simpler process for UASs below a certain size or capability. However, the SAC process will probably be the only avenue open to UAS operators entering civilian markets over the next 5 years, effectively limiting these markets to owner-operators. Service providers (and non-owner-operator customers) may appear in the following 5-year period, depending on the FAA's UAS Roadmap's recommendations.

When the 'real' civil unmanned aviation market that the above question anticipates does emerge, it will probably consist of existing airliners, such as freighters, modified to operate unmanned. Target drones provide an analogy; modifying formerly manned aircraft is preferable to acquiring a new drone design. It will probably not consist of orders for hundreds or thousands more Global Hawks or Predators or some new design UAS.

2.0 CURRENT UNMANNED AVIATION ASSETS AND INFRASTRUCTURE

2.1 Regional Attributes

Grand Forks, the Red River Valley, and North Dakota in general offer a number of natural “attractors” for unmanned aviation business, among them:

- North Dakota’s Congressional delegation is influential, supportive, accessible, and responsive on aviation matters.
- North Dakota has the infrastructure—7400 miles of highways, 3700 miles of railways, 90 airports, express delivery services, a public fiber optic network—already in place to accommodate new and expanding aviation opportunities.
- North Dakota state law for aviation insurance is among the most aviator-friendly in the nation.
- North Dakota’s climate offers 83 percent days/year of VFR weather, some of the nation’s best flying weather.
- North Dakota’s uncrowded skies (3.6 flying hours/square mile/year) provide a prudent arena for easing unmanned aviation into the National Airspace System. The odds of being in the same square mile column of airspace as another aircraft during a year average 1 in 2400.
- North Dakota’s combination of cold winters, low precipitation, and VFR weather provides an unexcelled environment for cold weather flight exercises and training.
- Grand Forks has the schools and curricula to produce an aviation-dedicated workforce.
- Grand Forks has the educated, stable, motivated, and productive workforce necessary to build, fly, and maintain aircraft.

2.2 Unmanned Aviation Cluster Strategy

The industry cluster approach is used to define the requirements for the necessary UAS infrastructure. Industry clusters are geographic concentrations of competing, complementary, or interdependent firms and industries that do business with each other and/or have common needs for talent, technology, and infrastructure. The firms included in the cluster may be both competitive and cooperative. They may compete directly with some members of the cluster, purchase inputs from other cluster members, and rely on the services of other cluster firms in the operation of their business.

Clusters may get their start in any number of ways. For example, a cluster may form around a large competitive firm, such as Microsoft in Seattle. The presence and support of a major research institution may spur the development of a cluster, such as the information technology clusters in Silicon Valley and the Boston area. Special infrastructure conditions or resources may also support the development of industry clusters. Examples include the wood products cluster in northern Minnesota, the wine industry in northern California, and tourism in southern Florida.

Industry clusters are dynamic entities. They may change as the industries within them change or as external conditions change. For example, as the computer hardware industry changed, the Twin Cities and Boston hardware clusters lost prominence in their states’ economies and nationally. Both areas are trying to rebuild their information technology clusters around new firms and new technologies. Sometimes an industry cluster will spawn an entirely new cluster. The aerospace cluster in Southern California has spawned several other clusters that rely on related engineering skills and technologies.

An important characteristic of clusters is that they are centered on firms that sell outside the local, state, or even national market. These exporting firms are driving forces in a regional or state economy. They bring money into the area and support many local industries. Clusters may include government, nonprofit organizations, educational institutions and other infrastructure and service providers whose presence is key to the strength of the cluster.[1]

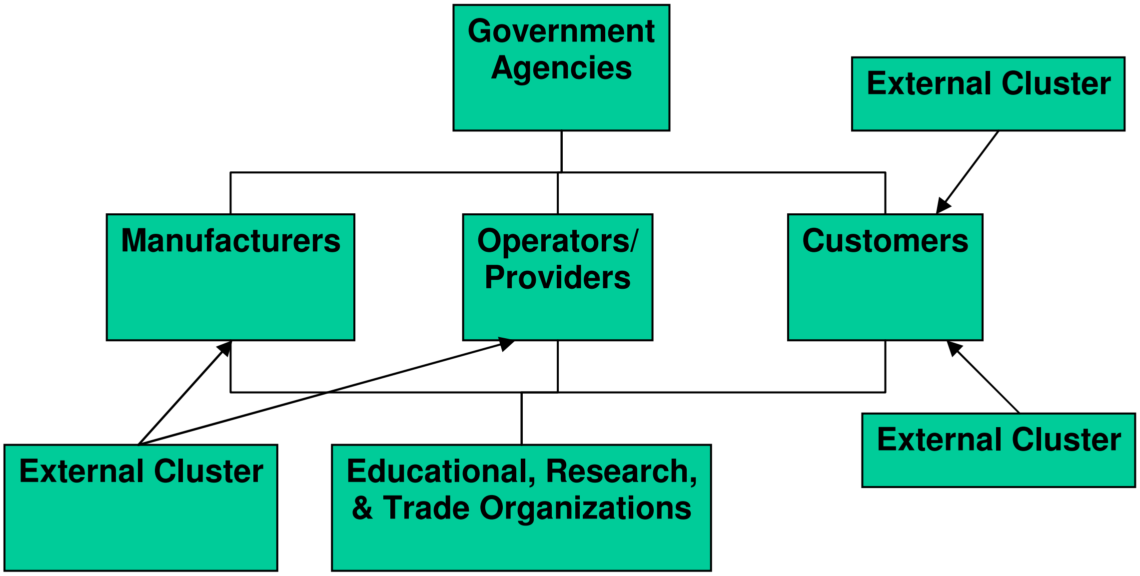


Figure 2-1. Depiction of an industry cluster.

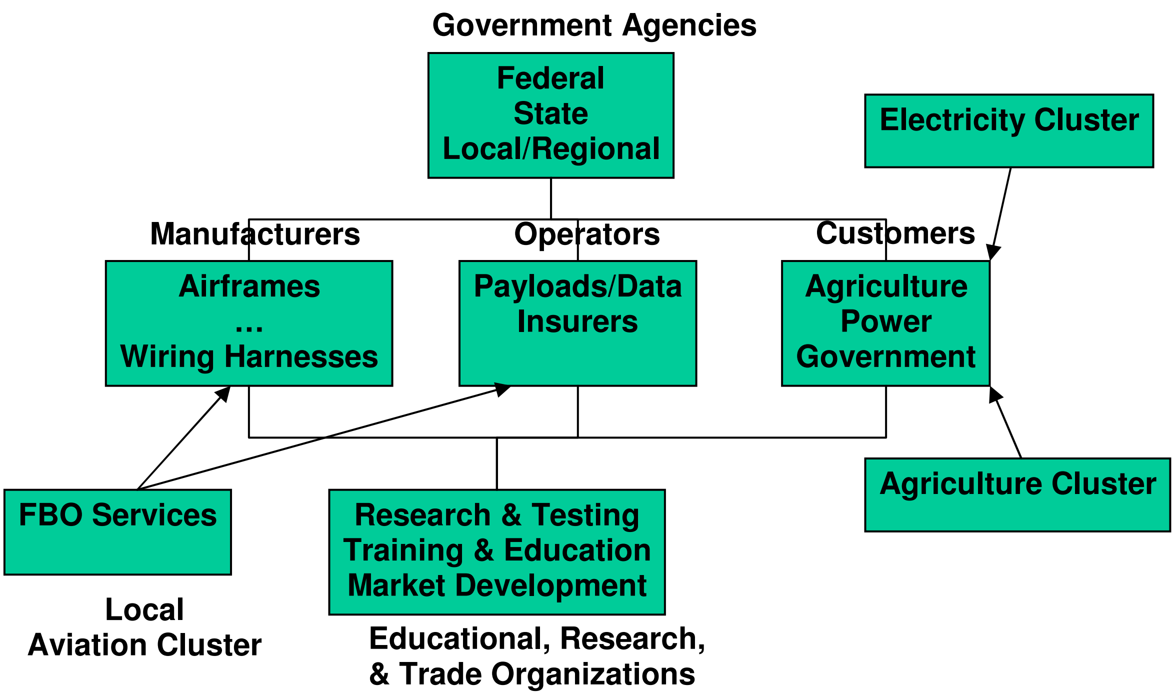


Figure 2-2. Depiction of an aviation industry cluster.

[1] Industry Clusters, An Economic Development Strategy for Minnesota, Preliminary Report, January 1999

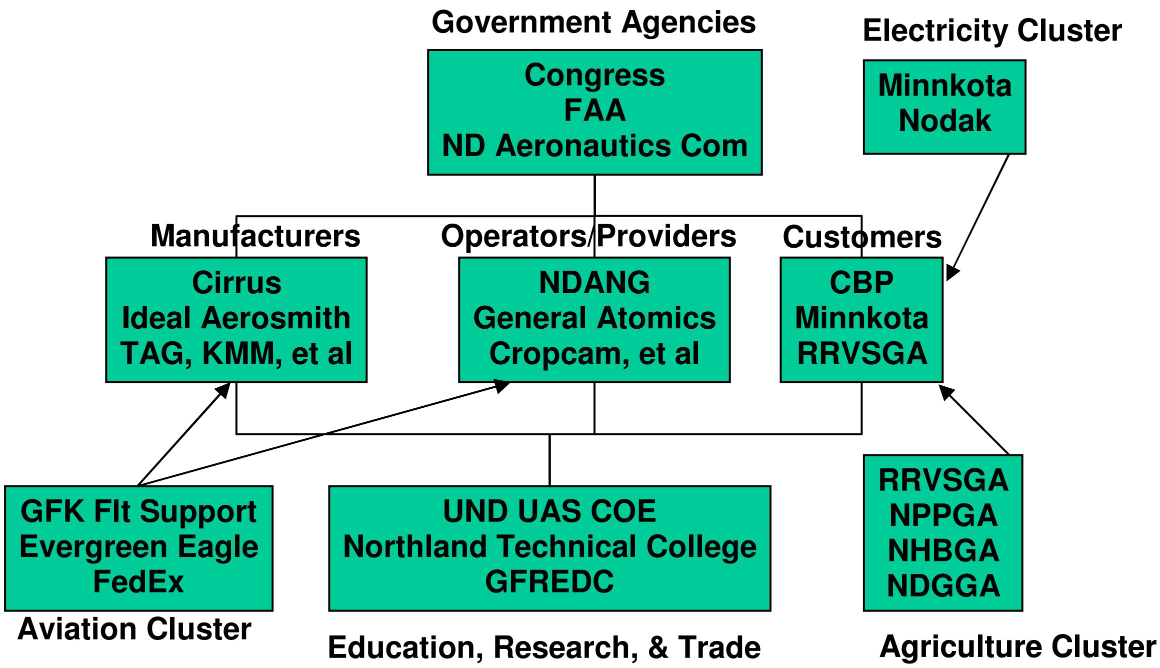


Figure 2-3. Depiction of the Grand Forks unmanned aviation cluster.

2.2.1 Government Agencies

2.2.1.1 Congress

North Dakota is represented in the U.S. Congress by Senator Kent Conrad (D-ND), Senator Byron Dorgan (D-ND), and Representative Earl Pomeroy (D-ND). Senator Conrad, now in his fifth term, sits on five Senate committees and six subcommittees, the most relevant to unmanned aviation being:

- the Subcommittee on Energy, Science, and Technology (which he chairs) of the Committee on Agriculture, Nutrition, and Forestry,

- the Committee on the Budget (which he chairs), and

- the Subcommittee on Energy, Natural Resources, and Infrastructure of the Committee on Finance.

Prior to holding elected office, he served as North Dakota's Tax Commissioner; he has no prior military experience.

Senator Dorgan, now in his third term, sits on four Senate committees and 14 subcommittees, the most relevant to unmanned aviation being:

- the Subcommittee on Commerce, Justice, and Science and Related Agencies and the Subcommittee on Defense both under the Committee on Appropriations,

- the Subcommittee on Aviation Operations, Safety, and Security, the Subcommittee on Science, Technology, and Innovation, and the Subcommittee on Space, Aeronautics, and Related Sciences of the Committee on Commerce, Science, and Transportation, and

- the Subcommittee on Water and Power of the Committee on Energy and Natural Resources.

Prior to holding elected office, he served as North Dakota's Tax Commissioner; he has no prior military experience.

Representative Pomeroy, now in his eighth term, sits on two House committees and five subcommittees, the most relevant to unmanned aviation being:

- the Subcommittee on Department (USDA) operations, Oversight, Nutrition, and Forestry, of the Committee on Agriculture and

- the Committee on Ways and Means.

Prior to holding elected office, he worked as a lawyer and in the insurance industry; he has no prior military experience.

2.2.1.2 Local FAA, NOAA, and Customs Offices

The Federal Aviation Administration operates the nation's 44th busiest air traffic control tower at Grand Forks International Airport, having some 266,000 operations/year, 94 percent of them by the University of North Dakota. It lies within the FAA's Great Lakes Region. The nearest Flight Standards District Office (FSDO) is located at Fargo.

The National Oceanographic and Atmospheric Administration's (NOAA's) National Weather Service (NWS) in Grand Forks is responsible for 17 counties in North Dakota and 18 counties in Minnesota. They are located at 4797 Technology Circle in Grand Forks and are responsible for providing weather, hydrologic, and climate forecasts and warnings for their regional responsibility.

Although no international flights serve Grand Forks, the U.S. Customs Service operates a station at the airport.

2.2.1.3 North Dakota Aeronautics Commission

Established in 1947, the North Dakota Aeronautics Commission is responsible for the state's aviation functions. The Governor appoints the five members to the board of the Aeronautics Commission for terms of five years. The Commission staff is composed of the Director and a support staff of four. It's office is located at the General Aviation Pilot Terminal on the Bismarck Municipal Airport, Bismarck. The state aviation system is an attractive front door to North Dakota's economic growth. To ensure this growth, the system needs continual enhancement with state-of-the-art technology. The commission is most interested in the advancement of unmanned aircraft systems industry in the state.

2.2.2 Manufacturer Profiles

The following sections profile the manufacturers comprising the Grand Forks region's unmanned aviation manufacturing cluster. Where data were not provided by the company, estimates are included in bracketed [italics]. Estimates of annual revenues were calculated by assuming Ideal Aerosmith's workforce is representative for this industry in this region (a few engineers and managers overseeing a large number of production floor personnel) and dividing its annual revenue figure by its number of employees to give an average rate of $125,000 per year per employee. Packet Digital's data yields a similar figure, $100,000. This figure consists of company-paid benefits, company overhead (lease, taxes, utilities, etc.), and the employee's salary, thereby providing a reasonable metric for estimating the total revenue brought into the region by a given company. The region's two largest aviation manufacturers (Cirrus and LM Glasfiber) are only manufacturing arms of their parent companies, meaning the corporate profits on their products (aircraft and wind turbines) occur outside the region at their respective points of sale (Duluth and Denmark) and are not (and should not be) reflected in this metric.

2.2.2.1 Company: Cirrus Design Corp. (CDC)

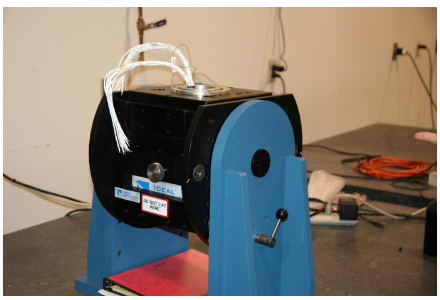
POC: Lee Anderson, Associate Director of Production, landerson@cirrusdesign.com, 701-335-4346
Founded: 1986, Grand Forks facility in 1996

Ownership: Private
Employees: 1200 total, 350 in GF
Annual Revenue: Not disclosed [*$44,000,000*]
- Sales Outside Region: 100% (all sales made from Duluth corporate headquarters)
Product(s)/Service: General aviation (4-passenger) aircraft; two models (SR-20, SR-22)
Competitors: Eclipse, Adam, Cessna, Diamond, Beech
Customers: Individuals, corporations, flight schools (3000 total aircraft sold by Nov 2006, 700+ sold in 2006, producing 800 in 2007)
Constraints
-Workforce Numbers/Education: 15 technician positions open/mechanical-industrial-materials engineers, fiberglass and resin handlers, quality insurance inspectors

-**Transportation:** none (by road)
-**Technology:** robotic routing, automated laser marking
-**Regulation/Taxation:** none
Why company located in GF: Local entities invested in company (1996)
Remarks: Serves as the manufacturing facility for parent Cirrus company; design, assembly, test, and sales occur in Duluth. CDC/GF employs 4 engineers and the rest are production floor personnel. Training is done by starting employees with the simplest parts then promoting them to more complex parts as they demonstrate competence, i.e., employees are productive from their first week. It ships fiberglass and carbon parts for 16 aircraft per week by road to Duluth. It also installs British-made titanium "weeping wing" anti-icing leading edges. CDC/GF has the capability to repair fiberglass and carbon airframes. Cirrus aircraft sell for $199,000 to over $500,000 with options. The fleet had accumulated 1.2 million hours through 2006. Cirrus also built the RQ-6 Outrider unmanned aircraft for Alliant Techsystems (Hopkins, MN) and the Army in 1997-99.

2.2.2.2 Company: Ideal Aerosmith, Inc. (IAI)

POC: Lonnie Rogers, President, lrogers@idealaero.com, 218-773-2455
Founded: 1938 (bought and relocated to East Grand Forks in 1984)
Ownership: Private
Employees: 112 total, 65 in East Grand Forks (EGF)
Annual Revenue: $14,000,000
-Sales Outside Region: 100%
Product(s)/Service: Dynamic motion simulation tables; build-to-print manufacturing
Competitors: Simtex (Texas), TBD Swiss company
Customers: Department of Defense, airlines, Smiths, Rockwell Collins, Honeywell
Constraints
-Workforce Numbers/Education: 2 electrical engineer positions open/2 months OJT required for production floor employees absorbed by IAI
-Transportation: none (by road)
-Technology: none
-Regulation/Taxation: none



Why company located in GF: Two of the 1984 investors were from EGF and recommended relocation there because of high rent in existing location (Cheyenne, WY).
Remarks: Builds dynamic motion simulation tables for testing inertial systems and build-to-print parts from vanishing vendors. Built with components from Switzerland, Germany, and East Grand Forks, its tables can be positioned to an accuracy of 1 arc second. Supported products include Smiths' flight mission computers, Rockwell Collins' weather radars, Honeywell's Enhanced Ground Proximity Warning Systems (EGPWSs), and Raytheon Sidewinder missiles IR seekers. Supported organizations include the Air Force and Naval Research Laboratories. IAI also has offices in Phoenix, Pittsburgh, and Menlo Park, CA. It is an ISO-9000:2000 certified, six sigma company.

2.2.2.3 Company: Killdeer Mountain Manufacturing, Inc. (KMM)

POC: Kristin Hedger, Business Development & Government Affairs, krhedger@hotmail.com, 701-426-9584
Founded: 1987
Ownership: Private
Employees: 320
Annual Revenue: Not disclosed [*$40,000,000*]
-Sales Outside Region: 100%
Product(s)/Service: Aircraft wiring harnesses; unattended ground sensors (UGS)
Competitors: None identified.
Customers: Department of Defense, Boeing, Lockheed Martin, Raytheon
Constraints
-Workforce Numbers/Education: Admin/IT
-Transportation: None

-Technology: E-commerce toolkit
-Regulation/Taxation: Barry Amendment; out-of-state excise taxes
Why company located in Killdeer: Founder dedicated to improving local economy.
Remarks: Builds wiring harnesses for the B-737 and B-777 airliners, as well as unattended ground sensors (UGSs) and radio frequency identification (RFID) tags for government customers.

2.2.2.4 Company: LM Glasfiber, Inc. (LMG)
POC: Gerald Muizelaar, Engineering Manager, grm@lmglasfiber.com, 701-780-9910
Founded: 1970s, 1999 at Grand Forks

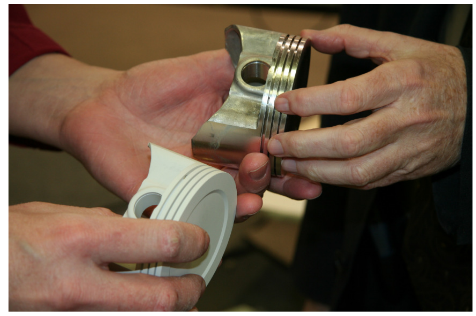
Ownership: Private (Danish company with British equity)
Employees: 650
Annual Revenue: Not disclosed [*$81,000,000*]
-Sales Outside Region: 100%
Product(s)/Service: Wind turbine blades
Competitors: None identified.
Customers: General Electric (US), Acciona (Spain), Gamesa (Spain), Vestas (Denmark)
Constraints
-Workforce Numbers/Education: 50-100 positions open/mechanical/industrial engineer, forklift & crane operators, fiberglass and resin handlers, QA inspectors

-Transportation: none (products go by road; customer picks up at plant)
-Technology: Automated layout, better ultrasound/radar QA testing
-Regulation/Taxation: OSHA 1-hour styrene emissions limit sets work pace
Why company located in GF: Post-flood incentives; prior relationship with a Crookston company; equidistant location for shipping throughout North America.
Remarks: Component supplier (blades) to parent company who assembles and installs wind turbines. Size of blades (203-foot length) presents transportation challenge. LMG has the capability to repair fiberglass airframes, but would need approval from corporate to diversify into this business (liability concerns). Parent LMG is strongly focused on just wind turbines due to its environmental beliefs. Similar production plants located in Spain, India, China, and Quebec. GF workforce has a 15-20% annual turnover rate.

2.2.2.5 Company: Technology Applications Group, Inc. (TAG)
POC: Bill Elmquist, President, belmquist@tagnite.com, 701-746-1818
Founded: 1989

Ownership: Private
Employees: 15
Annual Revenue: Not disclosed [*$3,000,000*]
-Sales Outside Region: 99% (to Arizona, Connecticut, Wisconsin)
Product(s)/Service: Anodizing magnesium castings by tagnite process
Competitors: Unique, environment-friendly process; competitors use chrome in process

Customers: Pratt & Whitney, Allison, Lockheed Martin
Constraints
-**Workforce Numbers/Education:** none/none
-**Transportation:** none (products go by road)
-**Technology:** Replacing resin coating with Teflon, ceramic coatings
-**Regulation/Taxation:** Environment regulations (potassium salts & fluoride)
Why company located in GF: UND spin-off



Remarks: Service supplier to magnesium casting companies for specialty (defense) applications. Magnesium weighs 70% of aluminum, but corrodes 30-40 times faster and costs five times more ($12/lb for Mg versus $2.50/lb for Al). Tagnite process creates a 0.0004-inch coat of magnesium oxide that makes its corrosion performance equivalent to that of aluminum. TAG can treat 80 feet in 20 minutes. After treatment, resin is cooked into anodized part to smooth its surface and allow it to be painted. Tagnite-treated magnesium parts are used in the F-22, F-35, AH-64, EFV, various helicopters, and a racing car.

2.2.2.6 Company: Packet Digital
POC: Joel Jorgenson, President, joel.jorgenson@packetdigital.com
Founded: 2003
Ownership: Private

Employees: 22
Annual Revenue: $2.2 million
-**Sales Outside Region:** 92%
Product(s)/Service: Wireless sensor networks, power management solutions, engineering services, radio frequency identification (RFID) tags
Competitors: TBD
Customers: American Crystal Sugar, Crane Advanced Wireless, Department of Defense
Constraints
-**Workforce Numbers/Education:** None
-**Transportation:** None
-**Technology:** None
-**Regulation/Taxation**: None
Why company located in GF: Located in Fargo, ND, for low cost of business and access to talent.
Remarks: Packet Digital has developed and deployed wireless sensors for identity preservation and cold chain/asset tracking. Its power management solutions enable wireless sensor networks to become miniaturized and to have extended operational life. It designs and develops advanced power management, smart RFID tags, and wireless solutions. Applications for its RFID technology include temperature and moisture monitoring of crops and container integrity for refrigerated shipments.

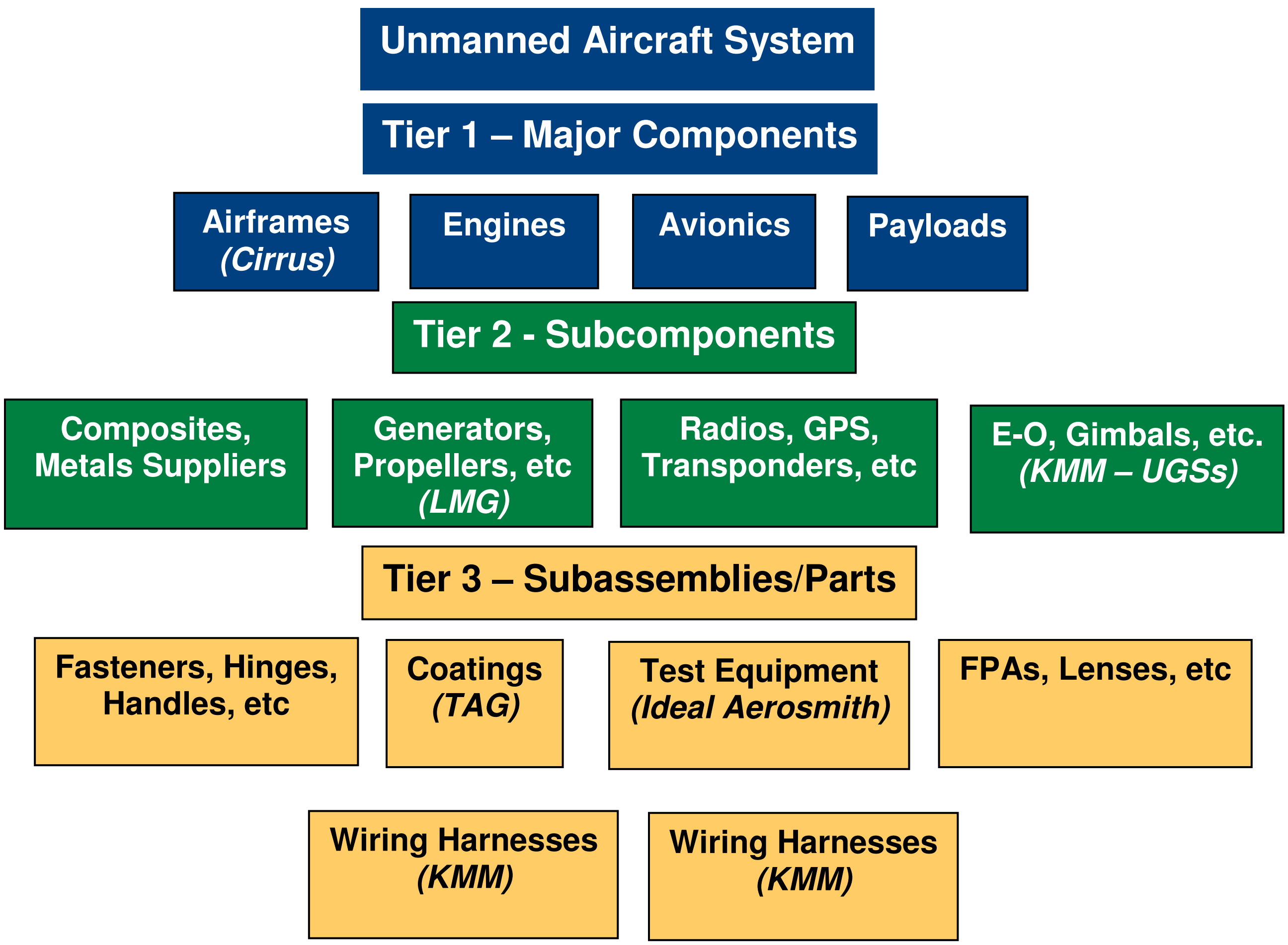


Figure 2-4. Local business roles in the aviation industry.

2.2.3 Operators Profiles

2.2.3.1 North Dakota Air National Guard

In its 2005 BRAC Recommendations, the Department of Defense recommended a realignment of Hector International Airport Air Guard Station, ND. BRAC recommendations announced the reduction in F-16 force structure at Fargo and the retirement of the 15 F-16s located at Hector International Air Guard Station.

The NDANG's 119th Wing has been assigned two new missions at Hector International Airport. Those missions are flying the Joint Cargo Aircraft and operating a Predator UAS ground control station in conjunction with personnel stationed at Grand Forks Air Force Base. The Guard will create a new maintenance unit at Grand Forks Air Force Base that will support Predator launch and recovery operations. The new maintenance squadron also may be tasked to support Global Hawk UAS operations once those aircraft arrive on base. Their Initial Operating Capability (IOC) by the second quarter of FY07 includes:

- Have the capability to operate one Remote Split Operation (RSO) Orbit 24/7/365.
- Have one Fixed Facility Ground Control Station (FGCS).
- Develop a Predator Operations Center in Fargo.

Their Full Operational Capability (FOC) to be developed by 2QFY10 includes:

- Capability to operate two RSO Orbits 24/7/365.
- 1 or 2 FGCS.
- 1 Mobile GCS.
- 1 Primary Predator Satellite Link (PPSL).
- 1 Launch and Recovery Element.
- 1 simulator.
- 8-12 MQ-1B Aircraft.

2.2.3.2 General Atomics Aeronautical Systems Inc.

GA-ASI, established in 1993 from parent company General Atomics and headquartered in Rancho Bernardo, CA, manufactures and operates several models of medium altitude, long endurance UASs. It employs some 2400 people and has manufactured nearly 200 Predators, Predator Bs, Gnats, Altairs, Altuses, and Prowlers for the Air Force, Army, Navy, Border Patrol, and several foreign countries. Under contract, it flys and maintains the Border Patrol's Predator B, and is expected to continue to do so for those eventually stationed at Grand Forks. An opportunity exists for Grand Forks to provide local employees to General Atomics for this contract or to establish a competing UAS services company that could assume this contract when it is recompeted. See www.ga-asi.com.

2.2.3.3 Cropcam

Cropcam, a division of MicroPilot Inc. of Winnipeg, Manitoba, manufactures the Cropcam UAS tailored for aerial mapping of farms and sells them both directly and through distributors, such as Pine Creek Precision LLC of Kendrick, Idaho (see www.cropcam.com and www.pinecreekprecision.com). MicroPilot, an autopilot manufacturer, was founded in 1985 and established Cropcam in 2005. The Cropcam UAS uses a 6-lb, battery-powered, modified RC model aircraft capable of mapping a 640-acre section in one flight of 25 minutes. The company also offers geographic information system (GIS) expertise in interpreting the UAS' data and training in its operation. The 2007 price for a one-aircraft Cropcam system was $9,900, with a one-week training course adding $500-1,000. Its competitors include AeroView International of Bowie, MD (www.aeroviewinternational.com) and Calmar Laboratories (www.calmarlabs.com) of Remington, IN. An opportunity exists for the region's growers associations to improve their crop yields by using one or more of these UAS's capabilities.

2.2.4 Customer Profiles

The following sections profile potential customers for unmanned aviation services comprising the Grand Forks region's unmanned aviation customers cluster.

2.2.4.1 Agriculture

Agriculture is the dominant industry of North Dakota, making it the local industry of choice for unmanned aviation to support, if possible. Unmanned aviation has an established role in precision agriculture, the application of technology to farming to increase the yield of crops. Japan has been using unmanned helicopters to plow, fertilize, and apply herbicides to its rice fields since 1990, Cropcam of

Canada (among others) has been offering imagery from unmanned aircraft for several years now, and UND students are testing a similar UAS/camera system.

Generally, precision agriculture is the use of remote sensing, such as multispectral imagery (MSI), to detect crop conditions such as diseases, over fertilization, water stress, and ripeness on a 'per acre' or even smaller scale to allow farmers to more narrowly and less expensively treat, and more profitably harvest, specific acres. As an example of the savings possible through precision agriculture, fertilizing a 640-acre section of potatoes (earning $100/acre) by cropduster can cost $3.50 to $8.00 per acre. If only one third of the acres actually needed fertilization, one third were sufficiently fertilized already, and the remaining third bordered on being overfertilized, then refertilizing the entire field would waste two thirds ($3400) of the application's cost and perhaps even destroy one third ($21,300) of the crop, resulting in a $24,700 expenditure/loss for a $21,300 gain. MSI combines aerial or satellite images of the same area taken in different wavelengths, called vegetation indexes, to highlight specific diseases or conditions. Based on MSI, fertilizer application can be tailored to the needs of specific areas within the field.

Using small UASs to image crops offers the potential for low cost, high resolution, timely support to farmers. Crop imagery from aircraft costs $2 to $6/acre, requires a 2-week advance notice for the flight, and delivers its imagery up to 2 weeks after the flight. Satellites offer free imagery, but their resolution is insufficient, and clouds can often preclude taking photos when needed.

North Dakota's 30,600 farms cultivate 39.3 million acres, employing 125 personal aircraft and 255 agricultural spray aircraft to support them. The table below summarizes the major crops grown in North Dakota's portion of the Red River Valley.

Crop	Sugarbeet	Potato	Bean	Wheat/Durum/Barley
Season Start	Late Apr/EarlyMay	Mid Apr/Early May	Mid May	Mid May
Season End	Early Sep/Mid Oct	Sep/Early Oct	Late Aug/Early Sep	Aug
Crops/Season	1	1	1	1
No of Crops (ND only)	261,000	66,000	318,800	931,000
No of Growers (ND only)	631	161	941	2273
No of Acres (RRV)	*610,000*	*80,500*	*398,700*	*2,294,200*
No of Growers (RRV)	*2,400*	*268*	*1,279*	*5,416*
Cost, $/acre	468	2000	220	200
Value, $/acre	1098	2400	315	300
Net, $/acre	630	400	95	100
Associations	RRVSGA	NPPGA	NBGA, NDDBC	NDGDA, NDGGA

Table 2.1. Summary of major crops in North Dakota's Red River Valley.

2.2.4.1.1 Sugarbeets

Customer: Red River Valley Sugarbeet Growers Association (RRVSGA, www.rrvsga.com)
POC: Greg Richards, grichard@crystalsugar.com
Opportunity: Long term; to provide precision agriculture services with UASs.
Losses: up to $6.3 million to $12.0 million/year
Discussion: North Dakota is the nation's second largest sugarbeet-producing state. The RRVSGA is composed of the American Crystal Sugar Company (www.crystalsugar.com) and the Minn-Dak Farmers Cooperative (www.mdf.coop) grower-owned cooperatives, who together represent 2400 growers, plant 610,000 acres, and operate 6 factories in North Dakota and Minnesota combined. The growing season

runs from late April/early May to harvesting in early September into October. One crop is harvested per season. The cost to the grower to produce this crop is some $468/acre, and the value averages $1098/acre. At an average net revenue to the grower of $630/acre and an average farm income of $260,000, the RRV's sugarbeet crop typically produces $384.3 million in annual revenue ($164.4 million in North Dakota alone).

Fungicides. Sugarbeet diseases most commonly encountered in the RRV are root (Rhizomania, Aphanomyces, Rhizoctonia, and Fulsarium) and leaf (Caercospora, Downy Mildew, Bacterial Leaf Spot, and Ramularia) infections. USDA Normalized Difference Vegetation Indices (NVDIs) for use with MSI exist for some of these diseases but not all. Root diseases are detected from the ground, can be mitigated by planting resistant varietals, but if unchecked will reduce the yield or cause the entire field to be destroyed. Leaf (foliar) diseases are also detected from the ground and reduce quality and yield but seldom cause a field to be destroyed. Annual losses to diseases are typically one to two percent of the total acreage, or some $6.7 to $13.4 million ($2.9 to 5.7 million in North Dakota alone).

Herbicides. Most growers make two to three herbicide applications per season for weeds, although some make up to seven. The majority of herbicides are applied with a ground applicator and a minority by aerial application. The annual cost of these applications (three) are some $21.2 million. Annual losses are very small (0.1 percent), or some $287,000.

Fertilizer. Dry and/or wet fertilizers are applied once at planting time and only rarely once leafs appear. Annual application costs total some $11 million. No crop losses due to over fertilization are documented.

Harvesting. Harvesting occurs in two phases, selected acreage in September's pre-harvest and the rest during the stockpile phase in October. The pre-harvest phase places a premium on high sugar content (higher quality), and growers are incentivized to select their top five to ten percent fields (based on projected yield) during this phase, when it is too warm for storage. Determination of quality is by hand sampling and follow-on analysis, a process that takes 24 inspectors and costs about $23,000. The remaining crop is harvested during the stockpile phase, which runs 7/24 until finished, typically during the first three weeks of October. During the winter, sugarbeets are stored outdoors in 240-foot wide, 1000-foot long piles, where heating can lower their sugar content.

Unmanned aviation equipped with MSI sensors could contribute by 1) early detection of diseases or water stress, 2) better tailored applications of pesticides, 3) improved selection of pre-harvest fields by MSI mapping, and 4) infrared monitoring of heat being generated in post-harvest storage piles.

Application	$/acre	$/crop	Apps/crop	% Lost	$ Lost	App Method
Herbicides	11.59	9,075,000	2-3	0.1	287K	Ground/Aerial
Insecticides	12.57	6,562,000	1-2	1-2	2,866K-15,840K	Ground/Aerial
Fungicides	25.85	6,747,000	1-2	1-2	2,866-15,840K	Ground/Aerial
Fertilizers	41.93	10,944,000	1	0	0	Ground
Water Stress			-	(0.1)	287K	-

Table 2.2. Summary of sugarbeet crop applications in the Red River Valley.

2.2.4.1.2 Potatoes

Customer: Northern Plains Potato Growers Association (NPPGA, www.rrvpotatoes.org)

POC: Rod Holth, KIP Farms
Opportunity: Long term; to provide precision agriculture services with UASs.
Losses: $23.8 million to $158.4 million/yr
Discussion: North Dakota ranks fourth among the nation's potato growing states, with the state's Red River Valley's 161 potato farms and their 66,000 acres producing $158.4 million ($26.4 million after costs). The NPPGA has 330 members in this community. The growing season runs from mid April/early May to September/early October; one crop is harvested per season. Typical cost is $2,000/acre and typical value is $2,400/acre, for a typical net revenue of $400/acre and an average farm income of $164,000.

Pesticides. Potato diseases most commonly encountered in the RRV are foliage, wilt, and tuber diseases. Foliage and wilt diseases are detected by visual inspection; tuber diseases require digging up plants for inspection. Insect infestations (aphids and leafhoppers) are also detected by visual inspection. Pesticides (fungicides and insecticides) are applied pre-emergent, weekly during the growing season after the six-week germination period, and pre-harvest, with all post-emergent applications done primarily by aerial spraying. Application and chemical costs average $370/acre. Prior to planting, fumigants are used to control early diseases, insects, and weeds, at a cost of $160/acre. Losses from diseases and insects range from none in a good year to 80 percent in a bad year.

Herbicides. Herbicides are also applied pre-emergent, during the growing season, and pre-harvest, with post-emergent applications done primarily by aerial spraying.

Water stress. Potatoes require a lot of water. During a dry cycle, up to 10 to 15 percent of the crop can be lost.

Fertilizer. Fertilizer (for dry land) is typically applied three times a season, once pre-emergent and twice during the season, usually through aerial application. The average cost per acre is $200. Losses due to over-fertilization are negligible.

Harvesting. Harvest decisions are based visually on maturity and size, with the three size categories being "French fries (plant dies down)," "potato chip," and seed (smallest).

Unmanned aviation equipped with MSI sensors could help reduce these $24 to 158 million per year losses by 1) early detection of diseases and infestations, 2) early detection of water stress, and 3) improved selection of harvest timing.

Application	$/acre	$/application	Apps/crop	% Lost	$ Lost	App Method
Fumigant	160	10,560,00	15	0-5	0-7,920K	Ground
Herbicides	370	24,420,000	2	5-10	7,920K to 15,840 K	Aerial
Insecticides	*	24,420,000	2-3	0-80	0 to 126,720K	Aerial
Fungicides	150	24,420,000	1	*	*Included above	Aerial
Fertilizers	200	13,200,00	1	0	0	Ground
Water Stress				10-15	15,840K to 23,760K	Irrigation

Table 2.3. Summary of potato crop applications in the Red River Valley.

2.2.4.1.3 Dry Beans

Customer: Northarvest Bean Growers Association (NBGA, www.northarvestbean.org); North Dakota Dry Bean Council (NDDBC)
POC: Mike Beltz, NDDBC
Opportunity: Long term; to provide precision agriculture services with UASs.
Losses: $26.1 million to 27.1 million/yr
Discussion: North Dakota ranks first among the nation's dry bean growing states, with the state's Red River Valley's 941 dry bean farms and their 318,800 acres producing $100.4 million ($30.3 million after costs). The growing season runs from mid May to late August/early September; one crop is harvested per season. Typical cost is $220/acre and typical value is $315/acre, for a typical net revenue of $95/acre and an average farm income of $32,000.

Pesticides. Dry bean diseases most commonly encountered in the RRV are blights and molds, such as nightshade, root rot, and rust, which are detected by visual inspection. Application and chemical costs average $15/acre and are done once a year, either through ground rig or by aerial spraying. Annual losses from diseases average 10 percent but vary due to wetness or dryness.

Herbicides. Ragweed is the typical weed requiring herbicide application.

Water stress. Up to 5 percent of the dry bean crop is lost annually due to water stress.

Fertilizer. Fertilizer is typically applied once a season by ground rig. The average cost per acre is $20. Losses due to over-fertilization are 1 to 2 percent.

Harvesting. Harvest decisions are based visually on moisture content (14 percent is typical decision point), determined by visual inspection and sampling.

Unmanned aviation equipped with MSI sensors could help reduce these $26 to 27 million per year losses by 1) early detection of diseases, 2) early detection of water stress, 3) better tailored applications of fertilizer, and 4) improved selection of harvest timing.

Application	$/acre	$/crop	Apps/crop	% Lost	$ Lost	App Method
Herbicides	10	9,564,000	2-3	5	5,021K	Ground rig/Aerial
Pesticides	15	4,782,000	1	5	5,021K	Ground rig/aerial
Fungicides	15	4,782,000	1	10	10,042K	Ground Rig
Fertilizers	20	6,376,000	1	1-2	1,004K to 2,008K	Ground rig
Water Stress			-	5	5,021K	-

Table 2.4. Summary of bean crop applications in the Red River Valley.

2.2.4.1.4 Small Grains (Wheat/Durum and Barley)

Customer: North Dakota Grain Growers Association (NDGGA, www.ndmarketmanager.org); North Dakota Grain Dealers Association (NDGDA, ndgda.org)
POC: Kyle Schafer, Agsco, Inc.
Opportunity: Long term; to provide precision agriculture services with UASs.

Losses: <$75.4 million to $131.3 million/yr
Discussion: North Dakota ranks first among the nation's small grains growing states, with the state's Red River Valley's 2,273 small grains farms and their 931,000 acres producing $279.3 million ($93.1 million after costs). The growing season runs from mid May to August; one crop is harvested per season. Typical cost is $200/acre and typical value is $300/acre, for a typical net revenue of $100/acre and an average farm income of $41,000.

Pesticides. Small grain diseases most commonly encountered in the RRV are leaf disease and scab, which are detected by visual inspection. Application and chemical costs average $17/acre ($5/acre for pesticides and $12/acre for fungicides), either through ground rig or by aerial spraying (preferred). Annual losses from diseases average 10 to 30 percent.

Herbicides. No data.

Water stress. Wheat is sensitive to too much or too little water, with either condition detected by visual inspection. Up to 5 percent of the small grains crop is lost annually due to water stress.

Fertilizer. Fertilizer is typically applied once a season by ground rig. The average cost per acre is $50. Losses due to over-fertilization are less than 2 percent.

Harvesting. Harvest decisions are based visually on maturity and to some extent moisture content, determined by visual inspection and sampling.

Unmanned aviation equipped with MSI sensors could help reduce these $75 to 131 million per year losses by 1) early detection of diseases, 2) early detection of water stress, 3) better tailored applications of fertilizer, and 4) improved selection of harvest timing.

Application	$/acre	$/crop	Apps/crop	% Lost	$ Lost	App Method
Herbicides	7.50	6,982,000	1	<5	13,965K	Ground Rig
Pesticides	5	4,655,000	1	<5	13,965K	Aerial/ground rig
Fungicides	12	11,172,000	1	10-30	27,930K to 83,790K	Aerial/ground rig
Fertilizers	50	46,550,000	1	<2	<5,586K	Ground rig
Water Stress			-	5	13,965K	-

Table 2.5. Summary of small grain crop applications in the Red River Valley.

2.2.4.2 Ranching

Customer: North Dakota Stockmen's Association (NDSA)
POC: Julie Ellingson, stockman@ndstockmen.org
Opportunity: Long term; to provide range surveillance services with UASs.
Potential Value: up to $1,700,000/yr
Discussion: North Dakota is home to 12,000 cattle ranchers and 1,750,000 head of cattle, who produce $525 million a year in revenue. Of this number, some 3 percent (52,000 head) are lost annually due to straying into gullies, downed fences, rustling ($230,000), predation ($1.5 million), or other causes. Each head is worth $1153 and each calf $405; 90 percent of rustling incidents go unsolved. An estimated 0.6 percent (75) of North Dakota stockmen fly aircraft (mostly VFR licenses) to keep track of their herds, find strays, and locate fence breaks. The use of radio frequency identification (RFID) tags on cattle is in its early stages. UASs could be useful in a role similar to that suggested for precision agriculture,

mapping fence lines and gullies, patrolling at night (usually IFR conditions) to deter rustlers, or serving as a relay for RFID tag transmissions.

2.2.4.3 Government

2.2.4.3.1 Customs and Border Protection

Customer: Customs and Border Protection/Air and Marine Operations (CBP/AMO)
POC: John Kimmel, john.kimmel@dhs.gov
Opportunity: Long term; to provide border surveillance with UASs.
Potential Value: $760,000/yr (UAS personnel only)
Discussion: CBP's Grand Forks Sector has 861 miles of Canadian border and 26 ports of entry across its eight states. Its focus is on interdicting terrorists and drugs. In Sep 2007, CBP/AMO will establish a detachment at Grand Forks consisting of 28-43 people (including 20 pilots) and 10-11 aircraft (4 fixed wing and 6-7 helicopters). CBP/AMO will be basing up to six Predator B aircraft and one ground control station at Grand Forks AFB starting in late 2007, with operations beginning in Mar 2008. The unit will be complete by 2012. When fully operational, up to four orbits will be flown simultaneously along the U.S.-Canadian border. The aircraft will be taken off and landed by one of three to four AMO pilots (average GS-12 salary $70,000/yr) and maintained by up to 12 General Atomics technicians (average salary $40,000/yr) based at Grand Forks; inflight, the aircraft will be controlled from the Air and Marine Operations Center (AMOC) in California via a satellite link. The UAS pilots will likely be dual qualified in one or more of the unit's manned aircraft.

2.2.4.3.2 Transportation Security Administration

Customer: Transportation Security Administration//Office of Intermodal Programs
POC: Kip J. Naugle, kj.naugle@dhs.gov
Opportunity: Long term; to demonstrate critical infrastructure monitoring with UASs.
Potential Value: $TBD/yr
Discussion: The Department of Homeland Security's Transportation Security Administration (TSA) is responsible for securing the nation's transportation infrastructure, including rail, oil, and gas lines, from terrorist attack. TSA personnel have expressed interest in evaluating UASs to help provide this security and attempted to fly a pipeline surveillance demonstration in Alaska with a MQ-9-like aircraft in 2004. The Tiger MOA has some 290 nm of Burlington Northern Santa Fe (BNSF) rail line and 160 nm of electrical transmission lines crossing it, providing a "target rich" environment for evaluating TSA concepts of operation for UAS use. A successful demonstration could lead to expanded, joint use of CBP's UAS by TSA and eventual local contractor support to TSA. See Long Term Objective (LTO) 4 in section 6.3.1. [2]

2.2.4.3.3 North Dakota Department of Transportation

Customer: North Dakota Department of Transportation
POC: Les Noehre, lnoehre@nd.gov
Opportunity: Long term; to provide mapping and imagery services with UASs.
Potential Value: $TBD/yr
Discussion: The NDDOT operates two fixed wing aircraft (four pilots) from Bismarck, primarily to transport state government executives, and is responsible for maintaining 106,600 miles of state roads and highways. The state also has 98 public-use airports. Its personnel participated in 3666 highway assists in 2006 and removed 2961 abandoned vehicles. It would use UASs to complement its manned

[2] MTSI has previously discussed demonstrating UAS use for critical infrastructure protection with interested TSA personnel.

aircraft by providing stereo imagery of potential highway routes for planning purposes and real time warning of road and bridge washouts due to spring flooding.

2.2.4.3.4 North Dakota Highway Patrol

Customer: North Dakota Highway Patrol
POC: Capt. Kevin Robson, krobson@state.nd.us
Opportunity: Long term; to provide search and imagery services with UASs.
Potential Value: $2500/yr
Discussion: The NDHP operates one fixed wing aircraft (two pilots) from Williston to help patrol its 7382 miles of highways, on which 101 fatal accidents and 111 fatalities occurred in 2006. NDHP also has a significant national role in securing our northern border; 80 percent of the U.S. Customs and Border Patrol's prosecutions in North Dakota result from NDHP stops. According to Sgt. Troy Hisher, Grand Forks District, North Dakota Highway Patrol, the Grand Forks District (counties of Grand Forks, Nelson, Pembina and Walsh) had 14 fatal accidents in 2006. These were single vehicle rollovers. In addition, it participates in two to three rescues and has to conduct 90 accident reconstructions annually. The NDHP utilizes 1 re-constructionist to conduct all accident reconstructions. The average time spent per reconstruction is approximately 2 hours per accident. Aerial imagery could potentially reduce this task to minutes. NDHP would use UASs to provide accident reconstruction images, unbroken surveillance of suspicious/criminal activity, search for missing persons, warning of flooded highways and bridges, and occasionally high speed pursuit.

The table below identifies all fatal accidents on North Dakota highways from 2003 to 2007 (to date).

Year	Motorcycle Fatalities	Ped Fatalities	Train Fatal	Other Fatal	Alcohol Related Crashes	Alcohol Related Fatalities	Total Crashes	Total Traffic Fatalities
2003	4	7	4	90	48	53	95	105
2004	9	5	1	83	38	38	95	100
2005	6	9	6	100	44	49	105	123
2006	4	4	0	103	44	44	101	111
2007	0	1	0	21	7	10	16	22

Source: North Dakota Highway Patrol.
Table 2.6. North Dakota highway accidents 2003-2007 (fatal).

2.2.4.4 Power Industry

Customer: Minnkota Power Cooperative (division of Touchstone Energy)
POC: Al Tschepen, atschepen@minnkota.com
Opportunity: Long term; to provide power line patrol services with UASs.
Potential Value: up to $200,000/yr
Discussion: Minnkota manufactures electricity at three power plants and transmits it over a 3000-mile network of high-voltage power lines to eight distributors in 33 counties in eastern North Dakota and northwestern Minnesota, an area of 33,000 square miles. Each hour of transmission earns $15,000, and Minnkota suffers an average of 100 one-hour outages annually, resulting in $1.5 million in lost revenue each year. These losses are minimized by patrolling their network of towers and power lines to spot potential problems (e.g., frayed wires, vegetation growth, right-of-way encroachments) before they cause outages. These patrols are conducted from the ground by a staff of eleven Minnkota personnel in

vehicles and from the air by leasing the services of Haverfield Corp. (Carroll Valley, PA) to overfly the lines by helicopter and fixed wing aircraft, according to the following table.[3]

Method	Voltage of Lines	Inspection Frequency	Miles of Line
Helicopter	345-240 kV	Once/year	600
Helicopter	135 kV	Once every other year	2600
Fixed Wing	345-240 kV	Six times per year	700
Fixed Wing	135 kV	Three times per year	400

Table 2.7. Summary of aerial power line inspections in the Minnkota region.

The helicopter patrols cost Minnkota $120,000/year or about $63/mile of line. The fixed wing patrols cost them $80,000/year or about $15/mile of line. Profit margins in the power industry are narrow (about 3 percent), so relatively small improvements or savings can have significant impact on profitability.

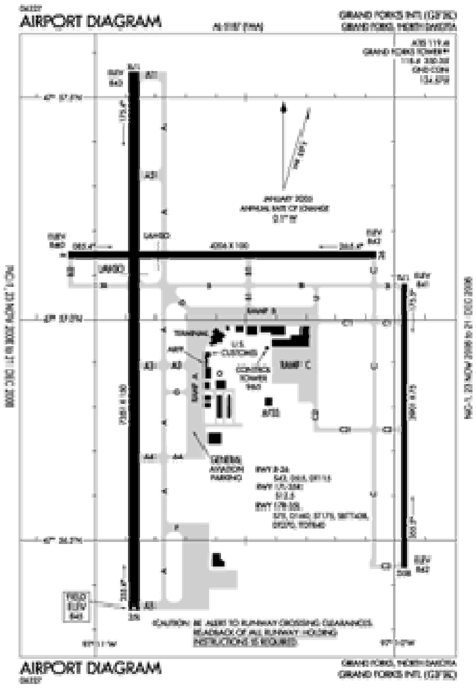
2.2.5 Aviation Cluster

2.2.5.1 Grand Forks International Airport

Grand Forks International Airport has three runways:

- Two for use by air carriers (17R/35L 7349 ft. long x 150 ft. wide and 8/26 4200 ft. long x 100 ft. wide)
- One for use by the general aviation community (17L/35R 3900ft. long x 75 ft. wide).

The air cargo apron is 700 ft. long x 340 ft. wide.
The feeder cargo apron is 400 ft. long x 225 ft. wide.



Air Carrier service is provided by four different airlines:

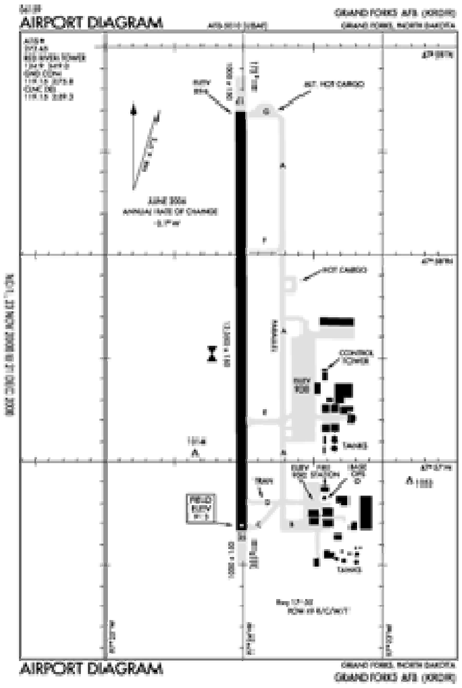
- Northwest
- Mesaba
- Pinnacle
- Corporate Air

The airport is also home to several other agencies including the University of North Dakota's John D. Odegard School of Aerospace Sciences. Others include U.S. Customs, the Transportation Security Administration, the Grand Forks Automated Flight Service Station, FedEx, and several rental car companies.

[3] MTSI has prior experience using both fixed and rotary wing UASs to inspect and inventory power lines.

2.2.5.2 Grand Forks Air Force Base

The Grand Forks Air Force Base (GFAFB) is located 14 miles west of the city of Grand Forks, and is the current home of the 319th Air Refueling Wing. The aircraft (currently) assigned to the 319th is the KC-135R Stratotanker. KC-135s provide aerial refueling to Air Force, Navy and Marine Corps aircraft as well as allied nations aircraft. The 2005 Base Realignment and Closure (BRAC) recommendations called for the realignment for Grand Forks Air Force Base. The impact of the BRAC involves the transition from a tanker wing to an emerging unmanned aerial systems mission to include the MQ-1 Predators and Global Hawks. The new mission will be a partnership with the North Dakota Air National Guard located in Fargo, ND.



The mission will establish a Predator MQ-1 Air National Guard unit at Hector International Airport Air Guard Station with an Active Duty Associate at the GFAFB, with the GFAFB serving as the home to MQ-1 AD/ANG association unit. GFAFB personnel will launch, recover, maintain and support MQ-1s assigned to 119 WG, ND ANG. The North Dakota Air Guard, housed at Hector International, will receive MQ-1 Ground Control Station(s) and serve as the "pilots" of the UASs to be bedded down at Grand Forks. The mission of the Predator is conducting armed reconnaissance against critical perishable targets. A fully operational Predator system consists of four aircraft with sensors, ground control station and Predator Primary Satellite Link, and 55 personnel for 24-hour operations. The Global Hawk Unmanned Aircraft System provides Air Force and joint battlefield commanders with near-real-time, high-resolution, intelligence, surveillance and reconnaissance imagery.

The deployment of unmanned aviation systems to the Grand Forks Air Force Base, according to the USAF Unmanned Aircraft System Program Plan developed and implemented by Headquarters Air Combat Command, is to see eight Predator MQ-1's and 2 Global Hawk RQ-4Bs bedded down at GFAFB in fiscal year 2010. Two additional Global Hawks will be added in the first quarter of 2011, with 4 Global Hawks being added from fiscal year 2011 (second quarter) through 2013.

While the Grand Forks Air Force Base has ample capacity and conditions for current and future flying missions, including the pending move to bed down a family of Unmanned Aircraft Systems (UAS) for DOD and the Customs and Border Protection fleet, there may be a need to modify infrastructure at Grand Forks AFB to fully accommodate the emerging Unmanned Aircraft System (UAS) mission. The Secretary of Defense will maintain eight KC-135 aircraft at Grand Forks Air Force Base to facilitate an efficient and cost effective bed down of UASs. The Secretary will keep the tankers in place until the UASs are operational at Grand Forks, but not later than the end of 2010 unless otherwise required by the Department of Defense for National Emergencies. Grand Forks will remain an active Air Force installation with a new active duty/Air National Guard association unit created in anticipation of emerging missions at Grand Forks.

There are currently three approved facility projects (as per USAF Unmanned Aircraft System Program Plan, Headquarters Air Combat Command) identified to address some of requirements mandated by this mission including:

- Construction of a MQ-1 AV gas tank (construction slated for FY08).
- Conversion of Hangar 521 doors for Predator casket storage (conversion slated for FY08).
- Conversion of Hangar 605 for MQ-1 corrosion control (conversion slated for FY08).

Some of the requirements, issues and challenges that confront the mission outlined for the GFAFB (and Air Guard) include both weather and regulatory issues relating to sense and avoid issues. Until a sense and avoid solution is available airspace access requires special work arounds. Regulatory and weather issues include:

- Local training airspace (MQ-1).
- Special use airspace for transition/check out sorties (RQ-4).
- Restricted airspace for operations.
- Radar monitoring by Remote Automated Radar Terminal Systems (ARTS) Color Display (R-ACD).
- Non-emergency and emergency divert airfields.
- A separate Letter of Agreement with Minneapolis ARTCC.
- There is a 10 Kt crosswind limit with a 150' wide runway.
- The RQ-4 Global Hawk's limitations in icing conditions.

2.2.5.3 Grand Forks International Fixed Base Operator (FBO).

GFK Flight Support is a full service FBO located on Grand Forks International airport that offers services in aircraft maintenance, aircraft charter, full line services and flight and pilot training leading to certification. Certifications they offer are:

- Private Pilot
- Instrument Rating Airplane
- Commercial Pilot
- Multi-Engine Land
- Certified Flight Instructor
- Airline Transport Pilot (ATP)

2.2.6 Educational, Research, and Trade Organizations

2.2.6.1 University of North Dakota UAS Center of Excellence

The UND UAS COE, located in Grand Forks, is composed of UND's John D. Odegard School of Aerospace Sciences, the School of Engineering and Mines, the Northern Plains Center for Behavioral Research, and the Center for Innovation. The Odegard School has departments in Atmospheric Science, Aviation (including majors in air traffic control, commercial aviation, airport management, aviation management and flight education), Computer Science, Space Studies, and Earth Systems Science and Policy. It offers one of the top two collegiate aviation programs in the world. Within the School of Engineering and Mines, both the Departments of Electrical Engineering and Mechanical Engineering offer degree programs with an Aerospace Focus/Concentration. UND's Psychology Department does research on issues relating to cognition and cockpit resource management. The College of Nursing does research on flight physiology. One member of the Aviation faculty, Dr. Warren Jensen, is a Designated Medical Examiner, a former Air Force flight surgeon, and an internationally recognized expert on human factors and flight physiology. While UND offers many of the courses relevant to developing and operating unmanned aircraft systems, no dedicated curriculum focused on unmanned aviation is currently available, although such a program is under development; this shortfall is addressed in 3.3.1.

2.2.6.2 Embry Riddle Aeronautical University
ERAU, located in the Grand Forks Air Force Base Education and Training Center, offers 2-year, undergraduate, and graduate degrees and certificate programs in aeronautics.

2.2.6.3 Northland Community & Technical College
NCTC, with campuses in East Grand Forks and Thief River Falls (MN), offers its nearly 3600 students 2-year degrees in over 80 areas of study. Of relevance to unmanned aviation are its Aviation Maintenance Technology, Electronics Technology/Automated Systems, Pre-Engineering Liberal Arts, and Robotics Technology/Automated Systems programs. Suggestions for additional programs are found in 3.3.2.

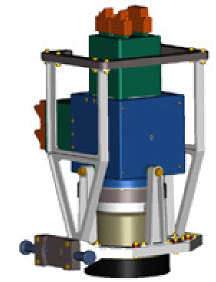
2.2.6.4 Lake Region State College
LRSC is a 2-year public college in Devils Lake, North Dakota with an outreach branch located at the Grand Forks Air Force Base. LRSC provides advanced training in simulators maintenance. The Simulator Maintenance Technician program at LRSC is one of the few training programs for simulator technicians in the United States. The program provides hands-on training in computer systems, digital and solid state electronic devices, printed circuit troubleshooting and variety of other systems essential to the operation of state-of-the-art simulators.

2.2.6.5 Grand Forks Region Economic Development Corporation
The mission of the GFREDC is to improve the quality and quantity of career opportunities for the citizens of the Grand Forks region. This region is loosely bounded by Hillsboro to the south, Devils Lake to the west, the Canadian border to the north, and the Minnesota border to the east, although economic ties into western Minnesota and southern Manitoba are recognized. Unmanned aviation is one of GFREDC's four targeted markets for expanding business and career opportunities in the region.

2.2.6.6 Upper Midwest Aerospace Consortium (UMAC).
The Upper Midwest Aerospace Consortium (UMAC) is dedicated to enabling public access by the people of the northern Great Plains and Rocky Mountain region to the benefits of NASA's Earth Science Enterprise. UMAC integrates academic, government, and industrial participants throughout the 5 states of North Dakota, South Dakota, Montana, Wyoming, and Idaho. Academic partners include the Universities of North Dakota, Idaho, Wyoming, and Montana, as well as Montana State, Sinte Gleska, South Dakota State, and North Dakota State Universities, plus the South Dakota School of Mines and Technology.

UMAC develops products and services for agriculture, natural resource management, and for K-12 education, using satellite imagery and other spatial technologies. They also provide information and educational outreach services to the general public with respect to regional impacts of environmental and climatic change. They provide products, services, and information to the general public by operating as a Public Access Resource Center, or PARC, focused principally on the agriculture, natural resource management, and education communities. Their main objective is to serve as a Public Access Resource Center, or PARC, for remote sensing data and related spatial technologies, principally for the people of the northern Great Plains and Rocky Mountain region.

Specifically, UMAC along with UND Aerospace and the School of Engineering and Mines (SEM) at UND are collaborating on a number of new initiatives to directly acquire remotely sensed images to better support end users. For example, the University of North Dakota has developed the Agricultural Camera (AgCam), which is a multi-spectral imaging system designed for use as a Sub-Rack Payload within the Window Observational Research Facility (WORF) onboard the International Space Station.



Additionally, UND's Airborne Environmental Research Observational Camera (AEROCam) is a multi-spectral aerial digital imaging system, capable of acquiring data in four visible and near-infrared bands. AEROCam is being developed through a unique partnership between private industry (DIGIT Inc.) and UND - the Upper Midwest Aerospace Consortium, the School of Engineering and Mines, and flight operations at the John D. Odegard School of Aerospace Sciences. Applications range from vegetative analysis (for research, agriculture, or natural resource applications) to disaster/rapid response, or any time a panchromatic, multi-spectral, or thermal aerial image is needed.

3.0 INFRASTRUCTURE REQUIREMENTS

3.1 Airspace

The number one infrastructure requirement for unmanned aviation in the Grand Forks region is airspace access. Under current FAA policies, unmanned flight can be authorized by one of three avenues:

- by Certificate of Authorization (COA), which allows unmanned flights by public aircraft for periods of up to one year for a specific aircraft type over specific areas/routes at specific dates/times under certain constraints. The process for obtaining a COA is advertised as taking 60 days, but 6 months is more typical recently.

- by Special Airworthiness Certificate (SAC) in the Experimental category, which allows unmanned flights by public or civil aircraft for periods up to one year for a specific aircraft (individual aircraft) for purposes of testing, training/proficiency, or marketing. The process for obtaining a SAC is currently running about 6 months and requires a detailed safety analysis of the aircraft, its system, and its planned operation to be submitted. Because UASs cannot be certified for commercial flights at present, a SAC for a civil UAS can only be issued to an owner-operator for his private use; no UAS owner may provide his services for hire.

- by flight in a Special Use Airspace (SUA) (recognized restricted or alert areas), which allows unmanned flight without restrictions within the SUA boundaries under the cognizance of the SUA using agency, typically a military service, and for the purpose(s) for which the SUA was justified. The using agency for North Dakota's one SUA, R-5401 Devils Lake, is the U.S. Army, Commander, Camp Grafton, North Dakota Army National Guard, who has recently expanded its purpose (artillery training) to include UAS flight operations. R-5401 is therefore available for UAS flights and is to be used for that purpose by ND Army National Guard RQ-7 Shadow units and others under Army auspices.

The infrastructure (standards, policies, technologies, etc.) for a fourth avenue, that of routine access to non-segregated airspace on the same basis as manned aircraft, or "file and fly," is under development but is not expected to be in place until the 2012-2015 timeframe. Although the provision of some form of "see & avoid" capability for the UAS is a key requirement for that future infrastructure, it alone is not sufficient to allow access to non-segregated airspace, as proposed by the Ganged Phased Array Radar System (GPARS) concept. A see & avoid capability could however be cited as a risk mitigation measure in a submission for a COA or SAC.

For military UASs, a forthcoming Memorandum of Agreement between the FAA and DoD (expected to be signed by June 2007) will allow DoD unmanned aircraft 1) weighing 20 lb or less to fly over government land (SUA not required) within line-of-sight (LOS) without a COA, and 2) of any type or number to fly within LOS from any Class D airfield that is not dual use under a COA, i.e., to conduct pattern work. This last provision is significant because it will allow COAs for specific locations instead of specific aircraft. These provisions are likely to be extended to DHS and will allow routine local area flying by Predators, Predator Bs (TBD), and Global Hawks from Grand Forks AFB.

Until this fourth avenue is in place, unmanned flight in the Grand Forks region by civil aircraft will be limited to user-owners of aircraft which have received SACs issued by the FAA. Public aircraft (Customs and Border Protection, Air National Guard, Air Force) could fly under either COA or SAC authorizations but under severe constraints. A better alternative would be to establish a restricted area, consisting of a corridor from Grand Forks AFB to and including the Tiger MOA for MQ-1/Predator training, RQ-4/Global Hawk climbs/descents to/from 50,000 ft MSL, and MQ-9/Predator B border patrols along 83 nm of the Canadian border. This could be done in two phases, establishing a temporary restricted area initially for a year to refine the three organizations' concepts of operations for using it, followed by establishing a permanent restricted area. Use of a SUA offers unrestricted flight within the designated airspace volume compared to that by COA or SAC. Its floor could be set high enough so as to not restrict transit by general aviation aircraft. The Aircraft Owners and Pilots Association (AOPA) will likely vigorously oppose the creation of such a SUA.

The table below summarizes the four avenues for UAS flight.

	COA Process	**SAC Process**	**SUA**	**File & Fly**
Applicability	Public only	Public & Civil	Public only	Public & Civil
Submission/approval process	60 days	4-6 months	10-34 months	1 hour
Duration of authorization	Up to 1 year	Up to 1 year	indefinite	indefinite
Aircraft applicability	Single acft	Single acft	All acft in area	Acft type
Flight restrictions, route	Specific route	Specific route	Anywhere in area	none
time	Specific times	Specific times	Block of time	none
other	Chase acft, etc.	Chase acft, etc.	none	none

Table 3.1. Comparison of airspace access options for UASs.

Airspace access, while critical, does not represent the total infrastructure requirement for unmanned operations. FCC approval to operate on the UASs' command and control (C2) and data transmission frequencies must be obtained. Within the proposed restricted area, emergency alternate airfields must be identified and possibly C2 relay facilities established. The latter may be necessary because the extreme (northwest) corner of the Tiger MOA is 130 nm from Grand Forks AFB, where the MQ-9 ground control stations (GCSs) will be located, making line-of-sight (LOS) communication impossible below 18,000 ft due to the Earth's curvature. The same northwest corner of the Tiger MOA is 185 nm from Hector ANGB, where the MQ-1 GCSs will be, making the minimum LOS altitude 35,000 ft. An education out-reach program for the region's general aviation community should be established to inform them of their new neighbors and their operating profiles, areas, times, and limitations.

3.2 Industry

The Grand Forks Unmanned Aviation Cluster described in 2.2 contains the necessary industries to operate and maintain UASs. It lacks members in three areas of expertise critical to the success and expansion of unmanned aviation however, communication links, payloads/sensors, and insurance.

For communication links, local expertise is needed in the FCC transmitter-use approval process as well as the installation and maintenance of both LOS and satellite (beyond line of sight, or BLOS) communication equipment.

For payloads/sensors, local expertise is needed for the maintenance and calibration of electro-optical and radar sensors and their gimbaled mountings. Ideal Aerosmith of East Grand Forks has expertise in developing avionics test equipment that could be applicable in both areas (see 6.3.3, LTO 14).

No insurance broker currently issues insurance for unmanned aircraft based on actuarial table rates. Only a few issue hull and liability coverage based on individual risk assessments and then usually at a rate of 10 to 20 times that for comparable manned aircraft. For commercial unmanned flight operations to become established on a sound financial basis, the operators will have to mitigate their risk of aircraft losses with insurance. By creating UAS actuarial tables, risk modeling software, and state-backed insurance funding, North Dakota has an opportunity to set a worldwide precedent in insuring unmanned aviation and expand that business beyond the region (see 6.3.3, LTO 16).

3.3 Academia

3.3.1 University of North Dakota

3.3.1.1 Undergraduate Programs

While UND offers many of the courses relevant to developing and operating unmanned aircraft systems, no dedicated curriculum focused on unmanned aviation is currently available. The military services are learning that while some aircrew skill sets are directly transferable from manned to unmanned operations, some old skills have increased in importance (human factors) and some new ones are now required (data link management). UND's John D. Odegard School of Aerospace Science is developing undergraduate and graduate degree programs in unmanned aviation, and UND has an opportunity to become the first university in the U.S., perhaps the world, to offer a degree program/concentration in unmanned aviation. Such a concentration could be constructed as follows:

Proposed Course	Similar UND Course(s)	Student Focus
Intro to Unmanned Aviation*	AVIT 101, 102	All
Airmanship	AVIT 102, 142 (cadet program)	Pilots
Aviation Weather*	AtSc 231	All
Data Links & Compression*	EE 411	All
Intro to Robotics	EE 428, EE 405	Engineers
Human-System Interfaces	AVIT 250	All
GPS and INS Navigation*	None	Engineers, pilots
Radar Sensing	EE 430, AtSc 441	Sensor operators
Electro-optical Sensing*	EE 456	Sensor operators
Electives	AVIT 103, 208, 222, 323, 324, 327; ME 446, 449	

Table 3.2. Summary of proposed courses for unmanned aviation concentration at UND.[4]

The proposed concentration would consist of 18 required and 3-6 elective hours in one of three tracks, pilots, sensor operators, or engineers. The former two tracks could come under the Odegard School and the last under the Engineering School. Such a curriculum could attract not only students from outside the region but research funding also.

The Odegard School is developing a 129-credit hour B.S. program in UASs. The plan is to add this degree to its current Commercial Aviation program. Discussions are ongoing with the College of Engineering & Mines to work out the details of the course offerings. The School is also contemplating a combined B.S. - M.S. degree program, where a student can apply in his/her senior year to enter what amounts to an honors program towards a Masters, so that they can complete the joint degrees in 5 years rather than the customary 6.

[4] *MTSI conducts/has conducted similar classes at the USAF Test Pilot School, Massachusetts Institute of Technology, Georgia Tech (awards continuing education credits), Linkoping University, and as part of the American Institute of Aeronautics and Astronautics professional development courses.*

3.3.1.2 Graduate Programs

Unmanned aircraft systems, as the name implies, requires a systems approach in their design, development, and operation. UND lacks a Systems Engineering curriculum, which is typically a graduate degree program that builds on an undergraduate degree in a specific engineering discipline.

3.3.2 Northland Community and Technical College

During surveys of local industries for developing this Roadmap, several of the companies identified recurring shortages of fiberglass/composite lay-up technicians, adhesives specialists, and quality assurance inspectors. One company estimated it cost him 3 months of salary (i.e., unsupervised, productive work did not begin until the fourth month) to train each such technician on the job. These specialty skills could form the basis for new certificate or diploma programs at NCTC. Basic fiberglass lay-up could possibly be taught as a local high school industrial arts course.

Future UAS operations in the region will require imagery manipulation and interpretation, driving needs for technicians skilled in photogrammetry, imagery analysis, and geographic information systems to create customer-useful products from UAS-obtained data. If UAS flights over the Red River Valley region began today, all of their imagery would have to leave the region for processing before being sent to its end-users, such as local farmers and grower associations. NCTC could help produce the technical workforce to convert these distant jobs into local ones, for regional, then extra-regional, markets.

4.0 POTENTIAL COMPETITORS IN THE UAS SECTOR

4.1 Regional Competitors

4.1.1 Smoky Hill Air National Guard Range, Salinas, KS

23-person flight oversees the largest and busiest ANG bombing range in the nation sitting under R-3601A. Smoky Hill encompasses 51 square miles of training space with over 100 tactical targets and an electronic warfare range. Located 10 miles west of Salinas KS, Smoky Hill provides realistic combat training for military aircraft and ground forces from all the military services. It also provides unmanned aircraft system support for selected users. AAI, manufacturer of the Army's RQ-7 Shadow UAS, chose Smoky Hill as its flight test center; Grand Forks was an alternative candidate.

http://www.ksmcco.ang.af.mil/RootFiles/iog.htm

4.1.2 Idaho National Laboratory, Idaho Falls, ID

With its access-controlled boundary, high-desert terrain and sparse population, INL is in a unique position to provide unmanned aerial vehicle and unmanned ground vehicle collaborative operational testing and demonstration, focusing on unique applications and missions for a wide variety of clients looking for affordable, field-deployable airframe technologies with meaningful payload and endurance.

INL's UAS program includes small, hand-launched UASs, unmanned rotorcraft (NRI), and runway or catapult-launched fixed wing aircraft (RnR APV-3 and Arcturus T-15). They own and operate a variety of affordable, multi-use R&D airframes ideal for ConOps development, sensor integration, multi-agent collaborative behaviors, and advanced autonomous sensor behaviors. Their other attributes include:

- 1000x100 ft runway
- In-place COA for UA flights
- NTIA "RF experimental test station" status, i.e., no frequency approval required

POC: nicholas.alley@inl.gov; 208-569-8402
http://www.inl.gov/nationalsecurity/capabilities/uav/?num=2
http://www.inl.gov/featurestories/2003-12-18.shtml

4.1.3 Camp Ripley, MN

The state-owned 53,000 acre Camp Ripley is a multi-faceted training center that balances the needs of the military, state agencies and communities statewide. Camp Ripley serves as a world-class military training center for all branches and components of service. Minnesota State Agencies also rely on Camp Ripley's exceptional facilities for training. Community interests across the spectrum of Minnesota life utilize Camp Ripley for its resources, expertise, and commitment to environmental stewardship. Representatives from Lockheed-Martin have been testing the Sky Spirit UAS at Camp Ripley since the middle of August, 2006. Camp Ripley is a unique area because the Camp not only owns the land, but also the air space (R-4301) over the training center. This provides a great benefit to UASs because the FAA's Certificate of Authorization (COA) process for flight authorization is lengthy.

http://www.minnesotanationalguard.org/press_room/e-zine/articles/index.php?item=147

4.1.4 Small Unmanned Air Vehicle Center of Excellence, Provo, Utah

The Center focuses on the rapid design of airframes and miniaturized autopilot and guidance systems for tiny unmanned aircraft that can be operated by novices. The Center has earned the attention of both military and civilian agencies.

http://goed.utah.gov/COE/clusters/aerospace/miniature_unmanned_air_vehicle/index.html
http://byunews.byu.edu/archive03-Oct-miniplanes.aspx

4.2 National Competitors

4.2.1 New Mexico State University, Las Cruces, NM

New Mexico State University's (NMSU) Physical Sciences Laboratory (PSL) established the UAS Technical Analysis and Applications Center (TAAC) in 1999 with the mission to promote safe integration of UAS in the NAS. The University of Hawaii and the University of Alaska are also active participants with the program. TAAC is a one-stop shop for critical technologies testing, routine flight operations, certification & regulatory research & validation, and planning for worldwide operations. Training can be provided for UAS operators, payload operators, and maintainers. Focus is on mid to small sized UASs. The base ground school, located at Las Cruces International Airport (no scheduled service), does include actual flying with two General Dynamics/Aeronautics Aerostars. They also develop training programs to fit specific needs.

http://www.psl.nmsu.edu/uav/

4.2.2 Embry Riddle Aeronautical University, Daytona Beach, FL

Embry-Riddle Aeronautical University has an interest in the development of both commercial and military UASs. Embry-Riddle currently has a number of UAS projects that are ongoing and has significant capabilities and expertise related to UASs within the following areas: UAV/UAS System Integration and Testing, UAV/UAS Simulation and Modeling, and UAV/UAS Policy and Training. It began sponsoring a conference on UAS commercialization in November 2005.

http://www.erau.edu/research/uavs.html

4.2.3 Pecos County Aerospace Development Center (PCADC), TX

Pecos County was identified as a candidate site to become a commercial spaceport in the 1998 Texas Aerospace Commission report. The Pecos County/West Texas Spaceport Development Corporation was formed in 2001 to oversee the effort to achieve this goal. At present, the Pecos County/West Texas Spaceport Development Corporation operates its spaceport as the Pecos County Aerospace Development Center (ADC) and it has experienced significant success during its first three years. More specifically, the Pecos County ADC has hosted numerous launches of suborbital rockets and unmanned aerial vehicles for paying customers and has sustained this effort locally as it waits for appropriated state funding.

http://www.governor.state.tx.us/ecodev/ecodev/aerospace/txspaceports/pecos_county/view

4.2.4 National Unmanned Systems Experimentation Environment (NUSE2)

A Department of Defense project, NUSE2 is a tightly coupled team of R&D, modeling, and simulation resources that provide the Nation with the capability to develop, evaluate, and support unmanned systems throughout the life cycle. NUSE2 will serve the entire unmanned systems (UAS, UGV, USV, and UUV) community as a long-term, life cycle resource. The Universities of Hawaii, Alaska, and

Wyoming are active participants in the program. NUSE2 provides the unmanned systems community unprecedented capability to conduct experimentation and promote technology transfer by fostering a synergistic and synchronized relationship between government, contractors, commercial, small business, and academia with scientists, technologists, product developers, testers, and users. The focus of this effort is the successful integration of all unmanned systems to include air, ground, surface, and underwater systems and the interoperability of those unmanned systems with manned systems on the joint battlefield.

http://www.jointrobotics.com/programs/nuse2.shtml

4.2.5 National Center for Defense Robotics, Pittsburgh, PA

The National Center for Defense Robotics, an initiative of The Technology Collaborative, procures federal funding for technology development projects intended to meet unmet government needs by transitioning agile robotics technology for current and planned unmanned military systems. The NCDR has established the Agile Robotics Alliance, a Pennsylvania-centric consortium of small companies, universities, government agencies, and defense contractors to undertake these projects.

The National Center for Defense Robotics (NCDR) announced that it was awarded a total of 15 task orders totaling $5.065 million and in turn awarded 14 robotics technology development project sub-contracts totaling $4.335 million to 13 companies and universities, including eight based in Pennsylvania and five based outside the state. This represents a substantial increase over the $1.3 million awarded to the NCDR and six tasks totaling $685,000 in turn awarded by the NCDR to its sub-contractors in FY05 (ending 9/30/05).

http://www.techcollaborative.org/default.aspx?id=NCDR

4.2.6 White Sands Missile Range, NM

While North Dakota can certainly be used as a cold weather test site, customers may find it inconvenient to wait for the precise conditions. WSMR has the capability to perform a wide variety of Climatic Tests at will in their climate chamber. WSMR maintains climatic environmental test chambers capable of high and low temperature, temperature shock, solar radiation, low pressure (high altitude), salt fog, rain (rain with wind), snow loading, icing/freezing rain, sand and dust, humidity, fungus and leakage testing are immediately available. A digital data acquisition system is used to acquire and process data. The system has the capability of acquiring data ranging from -100 degrees F to + 300 degrees F with an accuracy of +/- 1 degree for up to 150 channels. In addition, up to twenty transducers data channels (pressure, radiation intensity, etc) can be acquired with an accuracy of +/- 0.2 percent.

http://www.wsmr.army.mil/capabilities/st/testing/lab_fac/climatic.html

4.2.7 Sense-And-Avoid Display System, Inc. (SAVDS) of Mountain View, CA

Their marquee product is a notional UAS cockpit with a radar 3D display. SAVDS fuses UAS GPS location data with target data from Sentinel radar systems. Sentinel radar systems could be located miles from SAVDS using COTS wireless communications links. It could be co-located adjacent to UAB ground control stations to provide aircraft conflict data for immediate viewing by UAB pilots. SABDS could provide audible and visual warnings of potential aircraft/UAS conflicts. This is very similar to UND's proposed Ganged Phased Array Radar System (GPARS), but with NASA backing and experience flying UAS in California.

http://www.savds.com/index.php

4.2.8 University of Alaska, Poker Flat Research Range, Fairbanks, AK

Poker Flat Research Range, New Mexico State University, and the University of Hawaii have entered into a four-year contract, sponsored by the United States Air Force, to develop and coordinate future UAS operations within Alaska, Hawaii, and the western United States that focus on civil or scientific applications.

http://www.uaf.edu/news/a_news/20040713170931.html
http://www.pfrr.alaska.edu/pfrr/index.html

4.3 International Competitors

4.3.1 Robonic Arctic Test UAS Flight Centre (RATUFC), Finland

Robonic is an independent engineering company focusing on UAS launching systems and ground support. The company has a twenty year track record in the field and presently supplies its products to the global market for various target and tactical UASs.

Robonic also operates a dedicated UAS test flight centre in Lapland at Kemijarvi, Finland. Robonic provides a complete product range for various UAS types (from 22 to 2,200 lb). The designed maximum launching power is 8,500 kW accordingly. The systems are tested both with propelled and jet engine high performance target UASs. Robonic has arrangements with several UAS manufacturers and systems providers for existing and future programs.

http://www.robonic.eu/ratufc/index.html

4.3.2 Parc Aberporth, Wales, United Kingdom

The 50-acre Parc Aberporth technology park has been developed with government funding from the Welsh Development Agency (WDA) at the privately owned West Wales Airport. The $36 million facility's remote location on the UK's Atlantic coast makes it ideal for testing UASs in controlled airspace and proving the effectiveness of their sense-and-avoidance systems. The nearby 2,500-sq-mi Cardigan Bay has long been used for deploying and tracking military target drones. Next year, the airport's runway length is to be extended to just over 3,900 feet.

http://www.wda.co.uk/index.cfm/wda_properties/mid_wales_properties/parc_aberporth/links/en2832

4.3.3 Northern Europe Aerospace Test (NEAT), Sweden

NEAT offers the possibility to test and verify aerospace vehicles over the vast uninhabited areas of northern Sweden. Two restricted airspaces, each measuring approximately 2,315 square miles, are available for tests. There is also a possibility to temporarily link the two, and fly 217 miles one-way over more than 7,718 square miles - all over land.

http://www.neat.se/index.shtml

4.3.4 Aeronautics Operations, Yamaha Motor Co., Ltd., Japan

Yamaha Motor Co. Ltd began developing industrial-use, unmanned helicopters in the 1980s. Yamaha operates a small test area near Hamamatsu and Sky Academy, a school for training pilots for their remotely piloted helicopters.

http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA427393
http://handle.dtic.mil/100.2/ADA427393

In Table 4.1 below is a summary of competitors with values given to each attribute listed in the top row. All attributes were assigned a value of 1, except for special use airspace and training. Special use airspace received a value of 3 as that is three times as important as the other attributes. Training received a 1 or a 2. A "1" indicates they have trained personnel on staff. A "2" indicates they offer training classes. Values were totaled on the right. The higher totals indicate a stronger competitor with more attributes to their facility.

Table 4.1. Summary of competitors.

Location	Launch systems	Sim & Modeling	Runway	Hangar Facilities	Special Use Airspace	COA	Climate Chamber	Training	Integration & Test	WiFi/Broadband	FBO	Radio Frequencies	Living Accommo-dations	Total
Grand Forks			1	1						1	1		1	**5**
Nekoma										1			1	**2**
Camp Grafton					3								1	**4**
Regional														
Smoky Hill Air National Guard Range, Salinas, KS			1	1	3			1	1	1		1	1	**10**
Idaho National Laboratory, Idaho Falls, ID			1			1		1		1			1	**5**
Camp Ripley, MN					3			1		1			1	**6**
Small Unmanned Air Vehicle Center of Excellence BYU, Utah		1							1	1		1	1	**5**
National														
New Mexico State University/PSL/ TAAC, Las Cruces, NM			1	1	3	1		2					1	**9**
Embry Riddle Aeronautical University, Daytona Beach, FL		1	1	1					1	1	1		1	**7**
Pecos County Aerospace Development Center (PCADC), TX			1	1				1	1	1			1	**6**
National Unmanned Systems Experimentation Environment (NUSE2)		1	1	1	3		1		1	1			1	**10**
National Center for Defense Robotics, Pittsburgh, PA									1					**1**
White Sands Missile Range, NM			1	1	3		1	1	1	1			1	**10**

Sense-And-Avoid Display System, Inc. (SAVDS) of Mountain View, CA		1						1	1					**3**
University of Alaska Poker Flat Research Range, Fairbanks AK					3				1	1			1	**6**
International														
Robonic Arctic Test UAS Flight Centre (RATUFC), Finland	1		1	1	3							1	1	**8**
Parc Aberporth, Wales, United Kingdom										1			1	**2**
Northern Europe Aerospace Test (NEAT), Sweden			1	1	3								1	**6**
Aeronautic Operations Yamaha Motor Co., Ltd. Shizuoka, Japan		1	1	1				2	1	1		1	1	**8**

5.0 CURRENT AND LONG TERM UNMANNED AVIATION MARKET ASSESSMENT

The relative impact on today's National Airspace System by its five major user segments—airlines, air cargo, general aviation, business, and military--is shown in the accompanying pie chart as percentages of IFR air traffic volume handled by the ARTCCs. This accounts for virtually all airline, cargo, military, and business flying, but less than half of general aviation, with its high proportion of VFR flying. [Because each of these segments is changing at a different rate, similar pie charts were also created for 2025 and 2050, based on forecasts made from the data in the table immediately below them.]

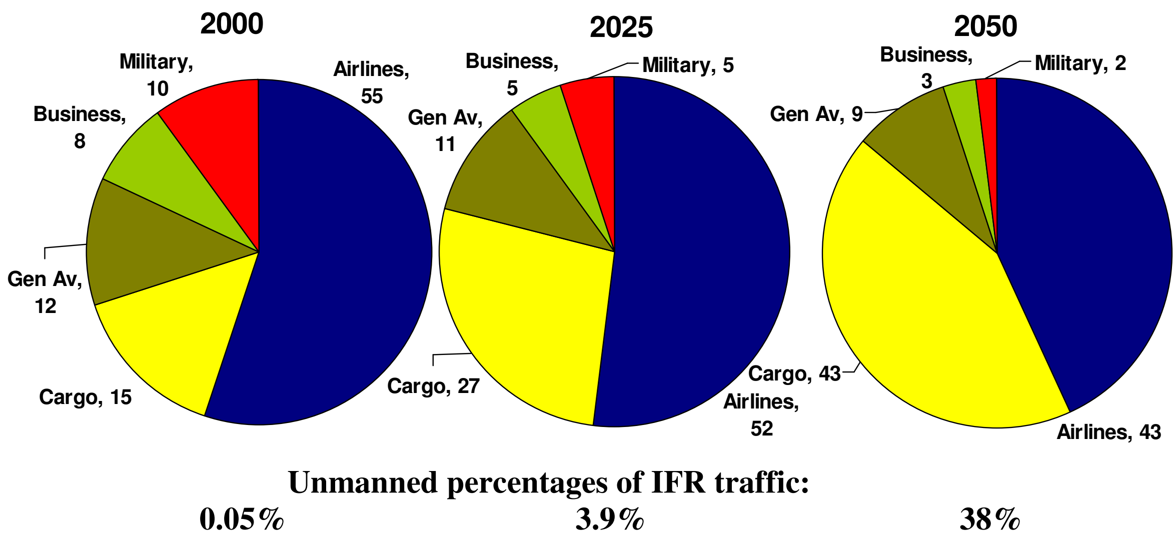


Figure 5-1. FAA forecast for IFR traffic for FY2025.

The degree to which unmanned aviation will impact NAS operations over the next 25 to 50 years depends on the timing and level of its acceptance in each of these segments, assuming these segments' shares remain relatively unchanged. It is apparent from this diagram that a large acceptance of unmanned aircraft in the near term by the military or business aviation segments would still not significantly affect NAS operations, whereas limited acceptance of them, even in the far term, in the airline segment would produce a significant impact. The perspective embodied in this last statement is critical to objectively assessing the potential of unmanned aviation to impact the future infrastructure of the NAS because the perspective (and expertise) of today's unmanned aircraft community (and the FAA) is focused solely on only one of these segments, the military. The following discussion attempts to quantify the extent to which unmanned aviation will likely impact the NAS in each of these five segments over the coming quarter to half century.

5.1 Airline Traffic

The major challenges to airlines accepting unmanned aircraft (as in passenger flight without a pilot onboard) are technology availability, pilot unions acceptance, and customer acceptance. The major technical hurdles are automating see and avoid, approach and landing, and ground operations.

Although an automated see and avoid system capable of avoiding midairs with cooperative as well as non-cooperative traffic is not currently commercially available, components of such a system are undergoing flight evaluation today (see the 2006 OSD/USN See & Avoid Flight Demonstration and the

2006 USAF/AFRL See And Avoid Flight Test experiments) and should be certified and available in a commercial package in the $20,000-price range within the next 5 years. TCAS provides such a capability today, but only for cooperative traffic and is not certified to tie into any flight control systems; its installed price is in the $150,000 to $250,000 range. Only two airline midairs (Germany, 2002 and Brazil, 2006) have occurred since the introduction of TCAS following the 1986 midair over Los Angeles, and it is noteworthy that one accident involved a pilot acting contrary to his TCAS advisory and the other to a pilot not having his TCAS turned on.

When the Los Angeles ARTCC lost its Voice Switching and Control System for 3 hours on 14 Sep 2004, ten of the 800 airborne flights in its sector violated FAA separation standards in the first 15 minutes, underscoring the single point failure implications of ground communications in today's NAS. Three points emerge from this incident, 1) human and TCAS see and avoid capabilities, even together, are still insufficient without ground (ATC) cueing to ensure safety, 2) Los Angeles ARTCC would have remained able to communicate with pilots of unmanned aircraft when it was not possible to do so with airborne pilots in this situation, and 3) this would have been a non-incident in the Free Flight environment being developed by FAA. TCAS is an interim measure, and the human eye is inadequate in certain collision scenarios, especially as air congestion increases. Automated, non-cooperative see and avoid is critical to manned aviation safety; it is not solely a requirement for unmanned aviation.

Of all phases of flight, landing is the most demanding of piloting skills and, by extension, the most challenging to automate in unmanned aircraft. Category 3 ILS-coupled auto-land, a ground-centric capability at selected major airport runways, has been available to most airliners for nearly two decades. More recently, Boeing's and Rockwell Collin's Global Landing System (GLS) has demonstrated an auto-land capability, using GPS combined with ground-based Local Area Augmentation System (LAAS) functionality, for any runway at any airport worldwide. Tests showed the ability to consistently auto-land within 3 feet of runway centerline, even in equatorial regions where GPS signals are least consistent. Both FAA and JAA have certified this system. Commercial availability of the Rockwell Collins GLU-925 GPS/LAAS receiver is planned shortly. As it must also be with future see and avoid systems, manned aviation safety was the dominant driver for GLS achieving FAA certification.

Of the three technology areas identified, ground operations has had the least effort undertaken on behalf of unmanned aircraft. However, its implementation can draw on the previous two technologies discussed, see and avoid for ground obstacle avoidance and landing for precision taxiing. This capability should be certified and commercially available in the 2010-2015 timeframe, assuming manned airliner ground operations are the dominant push.

Pilot unions accepting the removal of their members from airliner cockpits will arguably be the strongest challenge faced by unmanned aviation being accepted in the passenger-carrying role. History is against them, however. The chart below illustrates the decline in cockpit crew size since the introduction of passenger service.

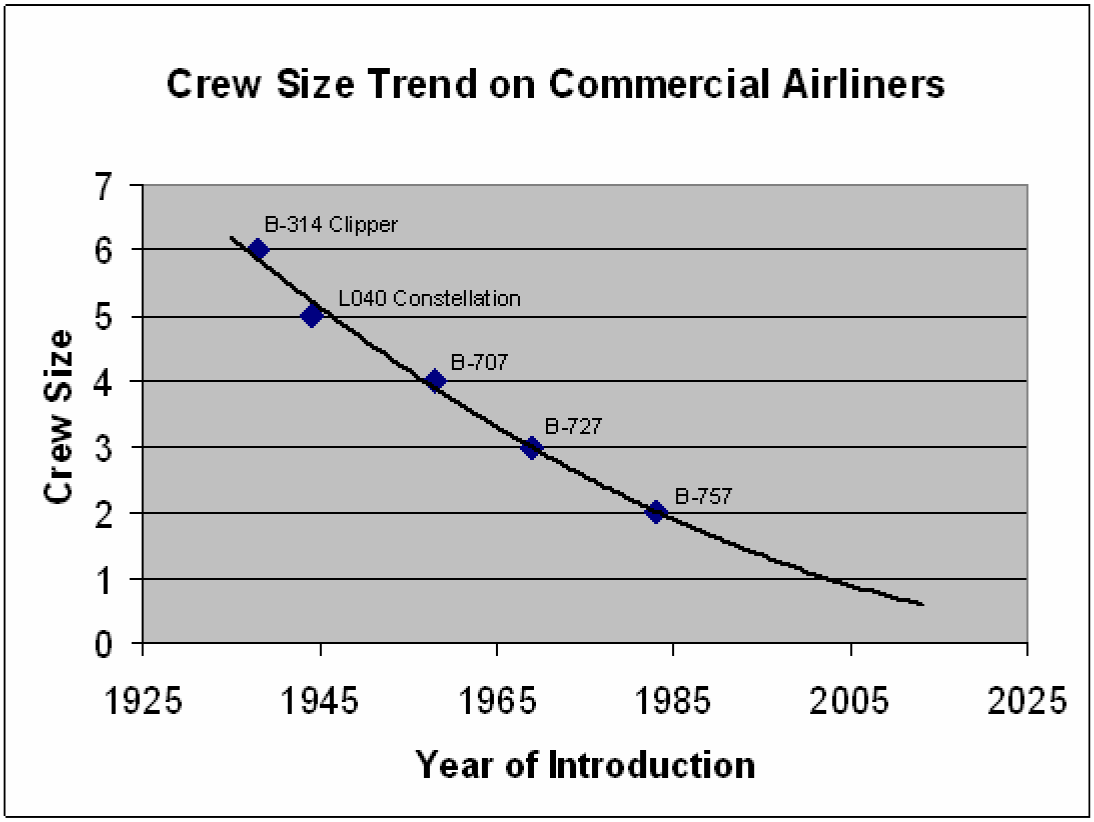


Figure 5-2. Crew size trend on commercial airliners.

This trend has occurred due to technical advances (INSs eliminated navigators, etc.) and its acceptance eased by the thin (or negative) profit margins and frequent pilot layoffs inherent in the airline industry. The trend predicts zero cockpit crew sizes in the post 2020 timeframe. While that may be realistic for air cargo, various factors will likely push this date out by a decade or two for airliners, but "roboliners" will debut sometime in the 2025-2050 period. Before the two-pilot crew gives way to the one-pilot one, pilot unions will undoubtedly raise the spectre of the single pilot being incapacitated in-flight by food poisoning or heart attack. Unfortunately, pilot suicides (SilkAir, 1997; EgyptAir, 1999) have proven to be a more frequent occurrence than medical anomalies. Robots are not subject in either case.

The recent experience of the railroad industry in adopting remote control locomotives (RCLs) for use in railyards is instructive on this point. After a decade of fierce union opposition, some 10 percent of U.S. locomotives are RCLs. In that time, the accident rate in railyards (which itself accounts for half of all U.S. rail accidents) has been cut in half, meaning total rail accidents have been reduced by 25 percent. Railyard-incurred injuries have been reduced by 57 percent, and the average cost per railyard accident by 34 percent. Union opposition, originally focused on accident rates increasing, has now shifted to expressing concern about the ergonomics of the RC-equipment harness and electromagnetic radiation hazards from the RC transmitters (less than from cell phones). For those who associate technology leadership with America, European railyards operate three times as many RCLs, and Canada began using RCLs a decade before the U.S.

Public acceptance of roboliner flight is inevitable and will not be the major barrier envisioned by many in the unmanned community. When elevators were introduced in department stores, elevator operators were employed to reassure the shopping public of their safety until the reliability of elevators was established in their mind. Has the reliability of elevators changed significantly between then and now? No, but the public's acceptance of them has. Similarly, the flying public has already accepted the elimination of registered nurses as flight attendants and the inclusion of women as pilots. When both pilots of a recent US Airways flight reported for duty intoxicated, their flight's passengers still filed onboard without questioning the sobriety of their replacements. When boarding, most passengers never even look left into the cockpit to see if the pilots are there. Those same passengers will unhesitatingly board a driverless tram to take them to other terminals. The fact that roboliners will not be subject to highjacker or terrorist demands may even make them preferable in some travelers' eyes. The flying public trusts the FAA to ensure the airlines are safe, so the FAA, not the public, may prove to be the "acceptance" barrier, if any. Once unmanned cargo aircraft demonstrate a record of safe, reliable flight over, perhaps, a decade, roboliner acceptance will follow.

In summary, the airline segment is driving the few remaining enabling technologies needed by unmanned aviation to enter into any segment; the last of these technical barriers (ground operations) will be overcome by 2010-2015. Union and public acceptance will follow in 2025-2050 once the FAA allows it. The airline segment presents the superset of barriers to unmanned acceptance, but each barrier will have been overcome one at a time in other segments by the time roboliners appear. Once the technical hurdles are overcome (2015), the FAA will dictate when, and industry economics how quickly, this transition occurs.

2025/2050 Forecast: Of the airline segment's 55 percent of total IFR air traffic handled in the NAS, 0 percent will be unmanned, or 0 percent of the total volume. By 2050, roboliners will have been introduced and will constitute between 0 and 50 percent (assume 25 percent) of airline IFR operations, or 14 percent of total IFR traffic.

5.2 Air Cargo Traffic

Well recognized within unmanned circles as its "great commercial hope," air cargo freighters seem to possess all the attributes--long, dull, over water missions--and none of the drawbacks --no passengers, hubs at secondary (Class C) airports--desired to initiate unmanned operations. They present only two of the three major challenges inherent in the airline segment, technology availability and union acceptance, and the latter as a much lower hurdle. The technology challenges are the same as those postulated for the airlines, and indeed the cargo segment is an equal driver for the auto-land capability. The cargo segment will likely begin transitioning to single pilot operations in the 2010 decade and unmanned operations in the 2020 decade, initially on long haul, transoceanic routes, followed by the longer overland routes, then the remainder. American (NAS) unmanned cargo operations will probably follow their introduction on Asian routes by 5-10 years. Asia is a likely proving ground because approaches to its major airports are over water (Singapore, Hong Kong, Narita, Inchon) and the air cargo market is experiencing its greatest growth in that regional market.

2030/2050 Forecast: Of the air cargo segment's 15 percent of total IFR air traffic handled in the NAS, 33 percent will likely be unmanned, or 5 percent of the total volume. By 2050, it should constitute 100 percent, or 15 percent of the total.

5.3 General Aviation Traffic

General aviation pilots fly for the personal satisfaction of flying, i.e., there is no motivation in this segment currently to transition to unmanned operations. Indeed, the present position of AOPA (as an organization, not necessarily its individual members) toward unmanned aviation is that it will pose a threat to the safety of its pilots. It fears the current generation of UASs (non see and avoid equipped), if allowed routine access to the NAS, raising the potential for mid-airs with its members as much as the superior see and avoid capabilities of future UASs raising the standard for them and requiring the cost of adding such a system to their aircraft. The intersection of general aviation and unmanned interests therefore occurs in the potential for mid-airs, making the major challenge in this segment the specific, previously addressed one of see and avoid technology. Ironically, the highest midair rate of any segment occurs among general aviation pilots, making them the primary beneficiary of the see and avoid technology being developed for unmanned aircraft. Making the cost of such a system low enough is key to acceptance by the general aviation population.

There is however a potential future development in general aviation that would drive a significant portion of it to embrace unmanned operations. NASA's Personal Aircraft System (PAS) program envisions a robust market for airborne commuters, i.e., non-pilots and families being flown short to medium distances in smart airplanes, within a generation. PAS is exploring the hardware and software requirements for such aircraft now and finding few technical hurdles enroute. Transitioning harried commuters from their one-dimensional worlds to one of three dimensions may seem quite a leap, but the subject of "mini-jets" presently seems to have equal or greater credibility than do unmanned aircraft in FAA's envisioned future. PAS, or mini-jets, are actually unmanned (or more properly, "fully automated"), in that there is to be no pilot onboard, with the rare exception of those passengers who happen to also be pilots. If PAS/mini-jets do come to fruition, they will help pave public acceptance of roboliners. If a commuter trusts his life daily to an automated aircraft, why not occasionally to an automated airliner? Before dismissing the possibility of a PAS/mini-jet society occuring in the next 25 years as illogical, consider how the logical requirements for a commuter vehicle (single passenger, high gas mileage, low weight for low taxes, small size for ease of parking) have somehow resulted in the large proportion of SUVs during rush hour.

2030/2050 Forecast: Of the general aviation segment's 12 percent of total IFR air traffic handled in the NAS, 0 percent will be unmanned, or 0 percent of the total volume. By 2050, assuming the introduction of a PAS-like market by 2030 and that it grows over 20 years at the same 8.28 percent exhibited for IFR handling by general aviation in the mid 1990s, 33 percent of general aviation, or 4 percent of the total, could be unmanned general aviation.

5.4 Business Traffic

Corporate jets represent aviation's express lane, flying the few at unscheduled times to unscheduled places to save them time. Their passengers were typically driven to and from the airport and expect to continue to be driven between airports, so the business aviation segment will be the last bastion of pilot chauffeurs. This segment's major hurdle to unmanned operations will be solely customer acceptance. Corporate pilots will be retained as status symbols as much as for any feelings of insecurity with automation. Seemingly, the frequent occurrence of high profile accidents in this segment (Golfer Payne Stewart, 1999; Governor Mel Carnahan, 2000; Senator Paul Wellstone, 2002) would encourage an eager and early transition to automated flight.

2030/2050 Forecast: Of the business aviation segment's 8 percent of total IFR air traffic handled in the NAS, 0 percent will be unmanned, or 0 percent of the total volume. By 2050, unmanned business aviation could mirror the overall general aviation trend and be 33 percent unmanned, or 2 percent of the IFR total.

5.5 Military Traffic

The military segment's adoption of unmanned aircraft faces one major hurdle, technology availability, specifically for the three capabilities (see and avoid, landing, and ground operations) described for the airline segment. Some would add customer (or union-equivalent) acceptance, pointing to what is termed the "white scarf mafia" or mentality, a reference to the objections of some military pilots who see flying with or against an unmanned aircraft as somehow unheroic and demeaning to their profession. Its better connotation is that it represents the conservative voice of progress within the military aviation community, those saying be wary of jumping to new technologies and concepts until they have proven themselves in combat. The pace of unmanned aircraft adoption by the military services reflects this cautious progress. The table below illustrates how the numbers of types and roles of unmanned aircraft have gradually increased with their use in each conflict of the past 15 years. In that time, unmanned aircraft have progressed from a few small types flying only imagery reconnaissance missions to over 20 types of large to miniature unmanned aircraft flying strike, diversion, and base security missions in addition to various modes of reconnaissance.

Conflict	Dates	UAV Types Deployed	Missions Performed
Persian Gulf	1991	Pioneer, Exdrone, Pointer, Mart (Fr)	Gunfire spotting, reconnaissance
Bosnia	1993-96	Gnat 750, Predator, Pioneer, Fox AT (UN), Crecerelle (Fr)	surveillance, reconnaissance
Kosovo	1998-99	Pioneer, Hunter, Predator, Phoenix (UK), CL-289 (Ger), Crecerelle (Fr)	surveillance, reconnaissance, target designation
Afghanistan	2001-present	Predator, Global Hawk, Dragon Eye, Pointer, Raven, Luna (Ger), Sperwer (Can), Tern	surveillance, psyops, reconnaissance, strike, target designation
Iraq	2003-present	Predator, Global Hawk, Hunter, Shadow, Pioneer, DarkStar B, Dragon Eye, FPASS, Silver Fox, Pointer, Raven, Tern, AQM-34, Phoenix (UK), Scan Eagle	surveillance, reconnaissance, strike, target designation, diversionary decoy, base security

Table 5.1. History of unmanned aircraft in conflict over the past 15 years.

Today, the U.S. military operates some 250 unmanned aircraft potentially capable of IFR operations and an equal number of smaller, model airplane-size (VFR-only) ones. The former represent two percent of all military aircraft. By 2010, the former number will triple and the latter will increase eight to ten fold. By 2020, these numbers could increase by similar multipliers again as the Army's Future Combat System and the Navy's Littoral Combat Ship come on line, both planned to be heavy employers of unmanned aircraft. The Coast Guard's Deepwater program envisions 76 of its planned 238 aircraft, or 32 percent, being unmanned by 2016; that number is zero today. These and various other programs' budgets provide a clear upward trend for the numbers of unmanned aircraft expected to be in the military segment by certain dates, as shown in the following table.

Service	2004	2010	2015
Air Force	80	165	250
Army	130	430	850
Navy/Marine Corps	35	75	175
Coast Guard	0	5	75
Totals	245	675	1400

Table 5.2. Numbers of unmanned aircraft to be in the military segment by 2015.

When compared with the Services' projections of the number of manned aircraft expected to be in their inventories by these same dates, the percentage of unmanned aircraft in this segment can be estimated, as is done in the table below.

2030/2050 Forecast: Of the military segment's 10 percent of total IFR air traffic handled in the NAS, 34 percent will be unmanned, or just over 3 percent of the total volume, assuming the 2020 projected inventory continues to triple each decade and triples again by 2030 (200 UASs today times 3 in 2010 x 3 in 2020 x 3 in 2030 = 5400 of the military's 16,000 air and rotorcraft). These percentages will likely continue to increase, to some 50 percent, or five percent of total IFR traffic by 2050.

5.6 Summary Forecast

In summary, 8 percent of the IFR traffic handled by FAA in 2030 is expected to be unmanned and, assuming PAS-like inroads into general aviation, 40 percent by 2050.

Segment	Number of U.S. Aircraft	% of IFR Traffic	Current % Unmanned	2030 % U/M Forecast	2050 % U/M Forecast
Airlines	5400	55	0	0	14
Cargo	1035	15	0	5	15
General Av	149,800	12	0	0	4
Business	37,500	8	0	0	2
Military	16,050	10	0.1	3	5
Totals	209,800	100	0.1	8	40

Table 5.3. Forecast of unmanned aircraft usage by 2050.

Manned and unmanned aviation tend to regard themselves as two separate (some would say incompatible), non-overlapping communities within aviation. The relationship between them should be viewed from the following perspective to gain a better perspective on how the unmanned side will impact the NAS in the future, because in the near future the distinction between the two will become blurred as people become passengers on automated (i.e., no onboard pilot) aircraft.

Aviation history has exhibited a long, continuing trend of pushing technology to automate the piloting function since its start in 1903. Only 8 years after the Wright Brothers flew (1911), Sperry demonstrated a prototypical autopilot, whose further development (by Sperry's company and others) produced the first commercial autopilots by 1930, 19 years later. These autopilots served as relief pilots, a desirable adjunct to the human pilot onboard but not a flight critical one; pilots began the transition from continuously flying to occasionally being flown. By the late 1970s, the autopilots in the F-16 and Space Shuttle had evolved into fly-by-wire (digital) flight control systems, necessitated by the numerous, continuous control inputs beyond the abilities of their human pilots. They were now flight critical components, having evolved from the first FBW system in the Mercury spacecraft nearly 20 years earlier. Without them, these aircraft were un-flyable, so pilots now transitioned from flying to being flown. FBW systems moved into airline cockpits when the Airbus A320 entered service in 1988 without a moment's hesitation from the passenger public. The next step in this evolution occurred in 1986, when DARPA's Condor made the first fully automated flight from takeoff to touchdown, a capability now productionized in Global Hawk (17 years later). Manual piloting in any phase of flight had now become unnecessary. The final step in this evolution will occur when automated aircraft are trusted to carry man as a passenger. The final enabling technologies, autoland and see and avoid, are becoming commercially available in the next few years, again after some 20 years of development. Whether as a stunt or as a serious demonstration, that milestone will almost certainly occur within the next 10 years.

6.0 BUSINESS DEVELOPMENT OPPORTUNITIES AND TAILORED STRATEGIES

6.1 Strategic Plan Objectives

Unmanned aviation is one of four economic growth sectors identified by the Grand Forks Region Economic Development Corporation (GFREDC) for pursuit by the Grand Forks region over the coming decade. The GFREDC's *Strategy 2007* establishes specific objectives and the action items and goals necessary for the region's expansion into the unmanned aviation sector over the next 10 years. The following sections link recommendations from this Unmanned Aviation Business Development Roadmap with the objectives of *Strategy 2007*.

6.1.1 Primary Objective: To increase the quantity and quality of career opportunities in the region with an emphasis on raising the quality of life. In the course of MTSI/CEO Praxis' interviews, the following companies identified immediate openings as shown in the following table.

Company	Engineers	Technicians	Total Openings
LM Glasfiber	1 industrial	50-100	51-101
Ideal Aerosmith	2 electrical	0	2
Cirrus Design	4 mechanical/industrial	15	19
Totals	7	65-115	72-122

Table 6.1. Summary of local companies' staff openings.

6.1.2 Objective 1: To raise the profile of and position the Grand Forks as a location for Canadian companies expanding into the U.S. GFREDC could approach Cropcam, a Stoney Mountain, Manitoba-based small business that maps Canadian farmlands with UASs with multispectral imaging to detect diseases, overfertilization, etc., then interprets these maps for farmers, about establishing its initial U.S. subsidiary in Grand Forks (www.cropcam.com) [addresses Action Item 1: Target and call on Manitoba companies that are selling into the U.S. marketplace]. GFREDC and/or UND could sponsor an exhibit at the next UVS Canada conference, to be held in St. Johns, Newfoundland, in Nov 2007 (www.uvscanada.org) [addresses Action Item 2: Attend and participate in conferences and events that will raise the profile of the Grand Forks region]. UND faculty/students could also submit papers for presentation at this conference. UND could join Aviation Alberta (www.aviationalberta.com), an network representing all the aviation aspects of western Canada [addresses Action Item 3: Maintain and expand existing networks in Manitoba, Saskatchewan, and Alberta].

6.1.3 Objective 2: In cooperation with UND, the State of North Dakota, and the Congressional Delegation, actively capitalize on the Grand Forks AFB realignment opportunity. The Enhanced Use Lease (EUL) option for attracting businesses with Air Force-relevant products/services to locate on Grand Forks AFB in return for reduced rent, could be used to lure aviation-related small businesses, such as Ideal Aerosmith and Omnetics, from Minnesota. See section 6.2.4 for Ideal Aerosmith's tailored strategy, while Omnetics, maker of connectors, would complement KMM's expertise in wiring bundles. [Addresses Action Item 3: Coordinate in partnership with the city and county, activities related to opportunities resulting from the GFAFB realignment and anticipated UAS mission.]

6.1.4 Objective 3: To leverage the Grand Forks Region's core capabilities in the Aerospace sector that results in the growth of that strategic sector. Prospects for aerospace-related companies locating in

Grand Forks to support its UAS operations include Raytheon (section 6.2.1, NTO 1), General Atomics (section 6.2.2, NTO 2), and Yamaha Motor Company and Cropcam (section 6.3.1, LTO 8). [Addresses a 12-month Goal: One solid aerospace-based company prospect, and a 5-year Goal: Two aerospace-related companies.]

6.1.5 Objective 4: To develop and sustain a highly regarded and effective marketing and communications program at the local, state, and national levels. MTSI will work with CEO Praxis and the GFREDC to create a continuing, world class conference on unmanned aviation commercialization, its issues and opportunities, with a focus on the Grand Forks region's attributes (UAS Action Summit on 26-27 Mar 2007). MTSI recommends UND also host a Media Day, in which top aviation editors are invited for briefings and tours of UND and GFAFB. Working with RTCA and the FAA, MTSI could help facilitate UND hosting an upcoming plenary meeting of the SC-203 UAS committee, composed of a number of the nation's leading experts in unmanned aviation, in Grand Forks. [Addresses Action Item 1: Hold two annual speakers events targeted at our members and general business community.]

6.2 Near Term Opportunities

NTOs are defined here as those business prospects that should be pursued immediately and could be generating revenue within the next 24 months (2008-2009 period). The criteria for selecting them are that they are not dependent on the FAA authorizing routine UAS access to non-segregated airspace. The 12 NTOs listed below are for UAS payload/sensor maintenance (three variants), human factors study (one variant) operations support (two variants), airmanship training (three variants), and material coatings (three variants). The payload and operations NTOs are dependent on the eventual arrival of the NDANG and CBP aircraft, however the training and coatings NTOs are independent of these events.

6.2.1 Business Attraction

NTO 1: The Raytheon AAS-51 gimbaled electro-optical sensors and laser designators being flown on the ANG MQ-1s and CBP MQ-9s require periodic alignment, calibration, and servicing. Raytheon also produces the combined electro-optical/synthetic aperture radar Integrated Sensor Suite for the RQ-4 Global Hawk. The substantial number (22+) of these payloads to be eventually deployed here should produce a constant, stable workload and justify the location of a Raytheon presence in the region to provide this service and return the payloads to operation in the minimum time (See NTO 10).
Estimated value: $250K (two people)/year.

NTO 2: General Atomics Aeronautical Systems, Inc., (Rancho Bernardo, CA), supplier of flight and maintenance personnel to CBP MQ-9 operations in Arizona, could create a long term operations office based here to support local CBP flights. Their Arizona office is manned by employees deployed from their relatively nearby California offices. The CBP however currently plans to partially assume this role from General Atomics and begin training its own pilots and sensor operators.
Estimated value: $1,000K /year.

NTO 3: General Atomics ASI currently employs Wichita State University to evaluate human factors aspects of its evolving, next generation Predator ground control station. UND's School of Nursing could potentially assume this role, partially or fully, due to the coming location of actual ground stations at Grand Forks and Fargo, assets not convenient to Wichita State.
Estimated value: $100K.

6.2.2 Business Creation

NTO 4: Same as for NTO 2 except for a new company, formed with experienced MQ-9 pilots and maintainers sourced from the Air Force and General Atomics, to assume this role. For local MQ-9 operations, CBP will likely be less willing to pay travel and per diem associated costs (and California salaries plus incentives) for General Atomics personnel deployed long term from California, and could welcome a competitive alternative. The recent (Mar 2007) award by the Air Force to Battlespace Flight Services for the maintenance of its Predator fleet at Creech AFB, NV, displacing General Atomics who had held the contract for years, shows this is a feasible opportunity. An early step in pursuing this opportunity would be to compile a list of MQ-1/MQ-9-qualified pilots and technicians from the local region (including ANG personnel from Fargo) who could provide a pool of prospective employees for such a company. ***Estimated value: $500K/year.***

6.2.3 Business Expansion

NTO 5: UND currently trains some 45 Army ROTC and West Point cadets annually to solo in helicopters in a 4-week, $1.3 million Army program. The Army will soon start procuring the Northrop Grumman MQ-8B Fire Scout, a rotary wing UAS based on the Schweizer 330, which is similar to Schweizer 300s in the UND fleet. The Army trains non-aviator enlisted personnel as its UAS pilots, who therefore lack airmanship. Lack of airmanship can contribute to mishaps and detract from mission effectiveness. Airmanship can be provided to future MQ-8 pilots by sending them through the same course UND now provides to cadets. Other potential benefits to offering this course are 1) attracting more and more high quality recruits into the Service and 2) incentivizing the students to focus on developing their piloting skills due to facing the solo "graduation exam." The Army plans to acquire 360 MQ-8s, and at a pilot:aircraft ratio of 2 and a tour length of 4 years, can expect to train 180 MQ-8 pilots per year. ***Estimated value: $5,200K/year.***

NTO 6: Same as NTO 5 except for future Navy enlisted MQ-8 pilots. The Navy plans to start deploying 114 MQ-8s on its Littoral Combat Ships in the last quarter of FY2008, and at a pilot:aircraft ratio of 2 and a tour length of 4 years, can expect to train 57 MQ-8 pilots per year. The present Navy Training Systems Plan for Fire Scout envisions rated officers serving as pilots, but this is expected to evolve to enlisted, non-rated "air vehicle operators." ***Estimated value: $1,600K/year.***

NTO 7: Same as NTO 5 except for fixed wing training for future Army enlisted MQ-1 Warrior pilots. The Army plans to acquire 132 MQ-1s, and at a pilot:aircraft ratio of 2 and a tour length of 4 years, can expect to train 66 MQ-1 pilots per year. ***Estimated value: $1,900K/year.***

NTO 8: UAS components made of magnesium could be made corrosion resistant and given longer lifetimes by being anodized with Technology Applications Group's (TAG) tagnite process. Such components are usually found in aircraft engines and coated with an epoxy paint to stem corrosion. Being a higher cost metal than aluminum or steel, magnesium components will probably tend to appear in the larger, more expensive UASs. Honeywell's TPE331 turboprop engine, used in the Predator B UASs being acquired by CBP as well as in numerous business jets, employs a magnesium gearbox nosecone; some 50-100 of these engines are manufactured annually; a total of 13,000 have been manufactured. TAG is presently a certified supplier to Honeywell.
Estimated value: $300K-700K/year.

NTO 9: Same as NTO 7, except for TAG anodizing engine components for the Air Force RQ-4 Global Hawk's Rolls Royce AE2007 engine, which also employs magnesium components. Between

100 and 200 AE2007s are manufactured each year, and some 2000 total engines have been built, primarily for business jet manufacturers. ***Estimated value: $70K-130K/year.***

NTO 10: Same as NTO 1 except Raytheon elects to subcontract this work to Ideal Aerosmith (see also NTO 10). Both the MQ-1 and MQ-9 employ gimbaled, inertially stabilized satellite communication (satcom) antennas with precision pointing and tracking abilities, both in the aircraft and at their ground stations. Ideal Aerosmith builds and tests such gimbals. Ideal could expand its business by becoming a subcontractor to the current UAS sensor and satcom antenna provider (Raytheon and L-3 Com) for gimbal test and calibration equipment (See NTO 1). ***Estimated value: $250K/year.***

6.2.4 Business Retention

NTO 11: Air Force personnel man the Precision Measurement Equipment Laboratory (PMEL) at GFAFB to support the KC-135s there. The PMEL is responsible for periodically inspecting and calibrating aircraft inertial and other systems. After the departure of the KC-135s, the PMEL will probably close. Ideal Aerosmith, due to its expertise in precision measurement equipment and inertial systems testing, could assume PMEL responsibilities for the incoming NDANG MQ-1 Predators. Department of Air Force civilians who had worked in the PMEL could apply for employment with Ideal, essentially retaining their jobs. Additionally, Ideal could occupy the former PMEL facility under an Enhanced Use Leasing (EUL) agreement with the Air Force (see NTOs 1 and 10).
Estimated value: $250K/year.

NTO 12: Alion Science and Technology's 11-person Surface Engineering Center within the Center for Innovation is on a 3-year "ticking clock" contract to develop innovative surface coatings. Anti-icing/deicing equipment options for UASs are "weeping wings" (costly, weight penalty), heating (power penalty), or shock (weight penalty, airframe stress). Development of a coating for wing, rudder, and inlet leading edges and control surfaces that sheds ice as it forms (or precludes its adherence) is needed. Second, Technology Applications Group, Inc., (TAG) is seeking improved coatings for its magnesium anodizing process. Success with either an anti-icing coating or a new TAG coating process could (1) extend Alion's contract work, (2) create a local business based on the anti-icing coating, and (3) expand TAG's existing market. ***Estimated value: $250K.***

6.3 Long Term Opportunities

LTOs are defined here as those business prospects that should not be expected to start generating revenue until routine access to non-segregated airspace by unmanned aviation is achieved (see "fourth avenue" discussion in 3.1). This will most likely not occur until the 2012-2015 timeframe. The 19 LTOs listed below are for UAS cold weather testing/exercises (three variants), law enforcement/security demonstrations (four variants), precision agriculture (five variants), ranching (one variant), inspections (three variants), airport operations (one variant), aerospace subcontracting (one variant), and insurance (one variant).

6.3.1 Business Attraction

LTO 1: AAI Corp. (Hunt Valley, MD), supplier of RQ-7 Shadow UASs to the Army and Marine Corps, has been forced to close its flight test facility at Farmville, Virginia, by the FAA. Its production acceptance and flight test operations have shifted to Salinas, KS, over 1500 miles away, using restricted airspace. Additionally, deployments of Shadows to Army and Army National Guard cold weather locations have begun, with systems now stationed at Ft Wainwright, Alaska (172nd SIB), Indian Town

Gap, Pennsylvania (29th ID), and Korea (1st and 2nd Bde, 2nd ID). Shadow's operational concept is to fly 50 km (27 nm) from its launch site and conduct 3 hour missions at 3,000 to 5,000 ft AGL at that radius. A restricted airspace overlapping the Tiger MOA/Nekoma complex could accommodate three non-overlapping Shadow orbits at/above 3,000 ft AGL within its 50 by 80 nm extent. Once operational, the Tiger MOA/Nekoma complex could be offered to the Army for winter training exercises with Shadow and potentially to attract AAI as a flight test base. In this context, "operational" means having FAA approval of this new restricted airspace (see 3.1). The Army's acquisition objective, with the inclusion of the Army Reserve component, is 88 total systems (352 aircraft).
Estimated value: $250K/year.

LTO 2: Same as NTO 1 except for Northrop Grumman (Rancho Bernardo, CA), supplier of the MQ-8 Fire Scout to the Army and the Navy. ***Estimated value: $250K/year.***

LTO 3: Same as NTO 1 except for General Atomics (Rancho Bernardo, CA), supplier of the diesel-powered MQ-1 Warrior to the Army. ***Estimated value: $250K/year.***

LTO 4: The Department of Homeland Security's Transportation Security Administration (TSA) is responsible for securing the nation's transportation infrastructure, including rail, oil, and gas lines, from terrorist attack. TSA personnel have expressed interest in evaluating UASs to help provide this security and attempted to fly a pipeline surveillance demonstration in Alaska with a MQ-9-like aircraft in 2004. The Tiger MOA has some 290 nm of Burlington Northern Santa Fe (BNSF) rail line and 160 nm of electrical transmission lines crossing it, providing a "target rich" environment for evaluating TSA concepts of operation for UAS use. A successful demonstration could lead to expanded, joint use of CBP's UAS by TSA and eventual local contractor support to TSA[5]. ***Estimated value: $50K.***

LTO 5: Similar to LTO 4 except the North Dakota State Patrol (NDSP) would assess the use of UASs for the tasks of imaging flooded out roads and bridges in real time, obtaining aerial accident reconstruction imagery (reducing task from hours to minutes), searching for missing/stranded people, surveiling suspicious vehicles, and engaging in high speed pursuits. Eighty percent of CBP prosecutions in North Dakota result from NDSP stops, making it possible CBP would contribute flight time with its MQ-9s to this assessment. ***Estimated value: $50K.***

LTO 6: Similar to LTO 5 except North Dakota sheriffs from local counties would assess the use of UASs for interdicting marijuana crops. ***Estimated value: $50K.***

LTO 7: Similar to LTO 5 except the North Dakota Department of Transportation (NDDOT) would assess the use of UASs for the tasks of mapping future highway routes and flooded highways and bridges. Photogrammetry specialists would need to construct maps from the UAS imagery.
Estimated value: $50K.

LTO 8: UASs are already established in precision agriculture in Japan and Canada, where they provide fertilizer and pesticide application services (Japan), as well as crop assessment imagery for detecting diseases, water stress, over fertilization, and ripeness (harvest planning) (Canada). The Red River Valley Sugarbeet Growers Association (RRVSGA) could acquire examples of these small UASs and evaluate them for use in improving local sugarbeet crop yields.
Estimated value: $300K (5% of losses)-$600K(10% of losses)/year .

LTO 9: Similar to LTO 8 except the Northern Plains Potato Growers Association (NPPGA) would use UASs for improving local potato crop yields. ***Estimated value: $1,200K (5% of losses)-$2,400K(10% of losses)/year .***

LTO 10: Similar to LTO 8 except the Northarvest Bean Growers Association (NBGA) and/or the North Dakota Dry Bean Council (NDDBC) would use UASs for improving local bean crop yields. ***Estimated value: $1,300K (5% of losses)-$2,600K(10% of losses)/year .***

LTO 11: Similar to LTO 8 except the North Dakota Grain Growers Association (NDGGA) and/or the North Dakota Grain Dealers Association (NDGDA) would use UASs for improving local small grains (wheat and barley) crop yields. ***Estimated value: $3,800K (5% of losses)-$7,500K(10% of losses)/year .***

LTO 12: North Dakota stockmen lose 52,000 head of cattle worth some $40 million annually due to predation, weather, rustling, and other causes. UASs could be used (see North Dakota Stockmens Association, www.ndstockmen.org) to monitor for predators and rustlers, as well as for checking reservoirs/tanks for sufficient water levels, locating downed fence lines, and relaying RFID tag signals once these tags are attached to cattle. ***Estimated value: $100K/year.***

LTO 13: Similar to LTO 4 except the Red River Water Basin Board would assess the use of UASs for inspecting dams and snow cover (depth) for runoff prediction. ***Estimated value: $50K.***

LTO 14: Minnkota Power spends $200,000 annually to hire airborne patrols of its transmission lines, a job that has been demonstrated to the power industry using UASs.[4] See LTO 4. ***Estimated value: $100K/year.***

6.3.2 Business Creation

LTO 15: Same as LTOs 8-11 except that a new business would form locally to compete with the same services now offered by the Japanese and Canadian companies, which would then spread beyond the state as airspace regulations allow. ***Estimated value: $100K/year.***

LTO 16: There will be a need to operate, house, maintain, and repair UASs at multiple locations throughout the state. Create UAS airports that cater to mostly, if not exclusively, UASs. This can be initiated by developing a relationship with the American Association of Airport Executives (AAAE). ***Estimated value: $100K/year.***

6.3.3 Business Expansion

LTO 17: Killdeer Mountain Manufacturing (KMM) manufactures wiring harnesses for Boeing airliners. If Cirrus Design could be persuaded to subcontract its 800 per year wiring harnesses to KMM, the local Cirrus Design manufacturing facility could ship both airframes and wiring harnesses together to the Cirrus assembly facility in Duluth. KMM should also approach General Atomics, maker of the MQ-1 and MQ-9, about assuming its wiring harness work for them. ***Estimated value: $500K/year.***

LTO 18: KMM manufactures unattended ground sensors (UGSs) for a government customer. Packet Digital has developed similar ground sensors for crop monitoring. Eighteen public roads cross the border between North Dakota and Canada and probably numerous private ones, most with one or no CBP officers at them most of the time. Planting UGSs at these remote or suspect border crossings could

help the CBP detect and monitor traffic at such points. KMM/Packet Digital could supply UGSs to the CBP, with data from the UGSs relayed via the CBP's UASs to its local stations.
Estimated value: $100K/year.

LTO 19: North Dakota's aviation insurance laws make it one of the more aviator-friendly states in the country. This edge in the manned aviation community could be expanded to make the State an early leader in insuring unmanned aviation also, thereby providing a strong business incentive for registering commercial UASs in the State (see 3.2). ***Estimated value: $250K/year.***

6.3.4 Business Retention

None.

6.4 Business Development Opportunities Summary

The 31 business development opportunities described in 6.2 and 6.3 are summarized in the following table.

Opportunity #	**Business**	**Description**
Near Term Opportunities		
NTO 1	attraction	Local Raytheon sensor service center (see NTO 10)
NTO 2	attraction	Local General Atomics ASI operations/maintenance detachment
NTO 3	attraction	UND human factors studies for General Atomics ASI ground station
NTO 4	creation	Newly formed local UAS operations/maintenance business
NTO 5	expansion	UND training of Army Fire Scout pilots
NTO 6	expansion	UND training of Navy Fire Scout pilots
NTO 7	expansion	UND training of Army Warrior pilots
NTO 8	expansion	TAG anodizing Honeywell TPE331 engine parts
NTO 9	expansion	TAG anodizing Rolls Royce AE3007 engine parts
NTO 10	expansion	Raytheon subcontracts sensor servicing to Ideal Aerosmith (see NTO 1)
NTO 11	retention	Ideal Aerosmith assumes GFAFB's PMEL responsibilities
NTO 12	retention	Alion development of anti-icing coating for UASs
Long Term Opportunities		
LTO 1	attraction	Cold weather test/exercise site for Army/AAI RQ-7 Shadow
LTO 2	attraction	Cold weather test/exercise site for Army/Navy/Northrop Grumman MQ-8
LTO 3	attraction	Cold weather test/exercise site for Army/General Atomics MQ-1C Warrior
LTO 4	attraction	Demo to DHS/TSA of UAS utility (rail/powerline surveillance)
LTO 5	attraction	Demo to ND Highway Patrol of UAS utility (accident reconstruction)
LTO 6	attraction	Demo to ND sheriffs of UAS utility (marijuana interdiction)
LTO 7	attraction	Demo to ND DOT of UAS utility (route mapping, flood warning)
LTO 8	attraction	Precision agriculture for RRV sugarbeet growers associations
LTO 9	attraction	Precision agriculture for RRV potato growers associations
LTO 10	attraction	Precision agriculture for RRV bean growers associations
LTO 11	attraction	Precision agriculture for RRV wheat growers associations
LTO 12	attraction	Cattle monitoring for North Dakota stockmens associations
LTO 13	attraction	Demo to Red River Water Basin Board of UAS utility (dam inspection)
LTO 14	attraction	Power line patrol for Minnkota Power
LTO 15	creation	Newly formed local precision agriculture UAS business (see LTO 8-11)
LTO 16	creation	Create UAS airports that cater to mostly, if not exclusively UASs.
LTO 17	expansion	Predator and Cirrus wiring harness work subcontracted to KMM
LTO 18	expansion	KMM/Packet Digital supply UGSs to CBP, monitored by UASs
LTO 19	expansion	ND insurance broker(s) offer UAS coverage

Table 6.2. Summary of near term and long term opportunities.

Table 6.3 attempts to categorize the 31 opportunities by their estimated annual revenue and the probability of their coming to fruition. Note that in some cases (e.g., the agriculture-related ones), the estimated revenue is an estimate of the value of *savings* resulting from preventing losses or efficiency gains. These estimates are highly speculative and depend heavily on the amount and quality of business development effort put into making them happen, i.e., the lower the assigned probability, the greater the required effort. The estimated combined value of the near term opportunities (NTOs) is $11,170,000 and that of the long term opportunities (LTOs) some $7,850,000. The latter figure assumes growers associations will be willing to spend 5 percent of the value of their potential crop losses for UAS services; if 10 percent is a more accurate estimation, then the LTO total becomes $15,350,000.

Estimated Annual Value			
$1M+	• **NTO 5** • **NTO 7** • **LTO 8** • **LTO 11**	• **NTO 6** • **LTO 9** • **LTO 10**	**NTO 2**
$100K-$1M	• **NTO 8**	• **NTO 4** • **NTO 12** • **LTO 2** • **LTO 3** • **LTO 17** • **LTO 18** • **LTO 19**	• **NTO 1** • **NTO 10** • **NTO 11** • **LTO 1** • **LTO 14** • **LTO 15** • **LTO 16**
$10K-$100K		• **NTO 3** • **NTO 9** • **LTO 4** • **LTO 13**	• **LTO 5** • **LTO 6** • **LTO 7** • **LTO 12**
Probability:	High	Medium	Low

Table 6.3. Estimated value and likelihood of opportunities.

6.5 Tailored Strategies

Given that specific points of contact and introductions for those opportunities identified in this Roadmap are not allowed, the recommended tailored strategy for most of the above opportunities consists of the following "stages" and "decision gates."

In the first stage, introductions are made and exploratory talks are held between the UAS-cognizant organization (such as UND, General Atomics, or Cropcam) and the potential customer for their services or products (such as the various crop growers associations). The key activity is arranging and facilitating the initial meeting(s) between the growers and the providers in this example. For the crop-related opportunities, the timing of the meeting should be no later than 3 months before the start of the respective crop's season. The first decision gate is for the customer (growers in this case) to decide if the opportunity merits the cost of a demonstration.

The second stage is a demonstration to evaluate the merits of the provider's service or product. The key activity is planning the demonstration so that it will yield quantifiable measures for its evaluation criteria. In the case of a precision agriculture demonstration, the criteria could include pounds harvested per acre and number of fertilizer or pesticide applications used on adjoining, equal-size fields, one monitored by UAS and the other not. It should run for the full growing season, usually 6 months. The second decision gate is determining whether the demonstration's results for crop improvement were sufficient to justify using UASs on a recurring basis.

If the benefit of the UAS approach is judged to exceed its cost, the third stage is business establishment. The key activity here is to sponsor or fund the start-up of a local business to provide this service on a regular basis. In this stage, the provider starts providing benefit to the Grand Forks region by increasing internal revenue (e.g., growers association to farmer) by generating more efficient yields. Once this start-up shows consistent profitability, perhaps over 3 to 4 years, the third decision gate is whether and where to expand the business.

If the business and its shareholders determine that it is financially mature enough to support additional markets beyond that of its original customers, the fourth stage is business expansion. In the case of UAS provider for crop monitoring, this expansion could occur into adjoining regions (Minnesota, South Dakota) with similar crops, then eventually into more distant regions with different crops. In this stage the provider's benefit to the Grand Forks economy transitions from providing operational (internal) savings to one of generating external revenue.

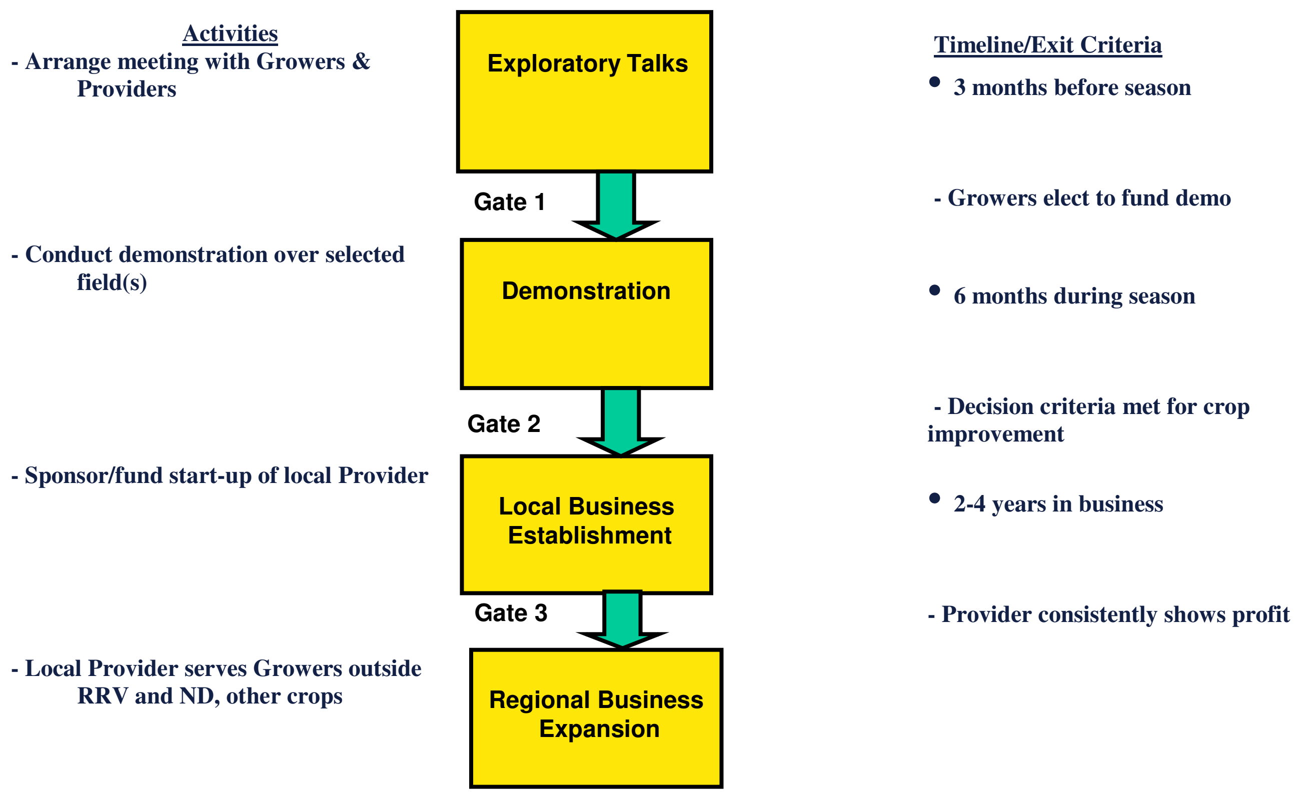


Figure 6-1. Tailored Strategies and Decision Gates Flow Diagram (agriculture example).

Appendix A: System Manufacturers.

State	Company	Location	Employees	Revenues	Customers
Alabama					
	Griffon Aerospace	Madison, AL	44	$7M	USA, USAF
	Teledyne Brown Engineering	Huntsville, AL	1,700	$280M	
	Neural Robotics, Inc.	Huntsville, AL	7	<$1M	
			1,751	$287M	
Arizona					
	Advanced Ceramics Research, Inc.	Tucson, AZ	80	$20M+	NOAA, NASA, NSF
	Thorpe SEEOP Corp.	Mesa, AZ	16	<$1M	USN
	Fly By Night Aviation	Hereford, AZ		<$1M	
	Miraterre Flight Systems	Tucson, AZ	3	<$1M	
	Northrop Grumman (TRW)	Sierra Vista, AZ	100		
			199	$20M	
California					
	AeroVironment, Inc.	Monrovia, CA Simi Valley, CA	168	$11.1M	USMC, NASA, DARPA
	BAE Systems Aircraft Controls, Inc.	Los Angeles, CA			
	Chapy Corp.	Sierra Madre, CA	6	<$1M	
	General Atomics Aeronautical Systems Inc.	Rancho Bernardo, CA	2,500	$150M	DHS, NCAA, USA, USAF, NASA, USG
	Lockheed Martin ADP	Palmdale, CA	180,000	$26.9M	USAF
	MLB Co.	Palo Alto, CA	6	<$1M	USAF, US Fish & Wildlife, Universities, Bolivia

State	Company	Location	Employees	Revenues	Customers
	Northrop Grumman RAC	Rancho Bernardo, CA	1,000	$300M	USA, USAF, USN
	Tactical Aerospace Group	Beverly Hills, CA	42	<$1M	Foreign
	GT Aeronautics, LLC	Simi Valley, CA	5	<$1M	
	RnR Products	Milpitas, CA	6	<$1M	
	AC Propulsion	San Dimas, CA		<$1M	
	Arcturus UAV	Rohnert Park, CA		<$1M	NRL, INL
	Mission Critical UAV, Inc.	Los Angeles, CA	6	<$1M	
	Moller International	Davis, CA	20	$3.5M	
	Trek Aerospace	Acampo, CA	4	<$1M	
	NextGen Aeronautics, Inc	Torrance, CA		$2.5M	
			183,763	$494M	
Connecticut					
	Flightstar, Inc.	Ellington, CT	10	$2M	
	Sikorsky Aircraft Corp.	Stratford, CT	9,300	$2,100M	
			9,310	$2,102M	
Florida					
	Cyber Aerospace Defense Technologies	St. Petersburg, FL	15	$3.5M	
	Autonomous Unmanned Air Vehicles (AUAV)	Palmetto, FL	3	<$1M	
	Octatron	St Petersburg, FL			
	Systems Research and Development Corp. (SRDC)	Palm Beach Gardens, FL	15		
	Aviation Instrument Technologies	Zephyr Hills, FL			

State	Company	Location	Employees	Revenues	Customers
	Hanley Innovations	Ocala, FL	2	<$1M	
			37	$3.5M	
Hawaii					
	Williams Aerospace, Inc.	Ewa Beach, HI	6	<$1M	
			6	<$1M	
Indiana					
	American Aviation Co.	Peru, IN		<$1M	
				<$1M	
Kansas					
	Viking Aerospace	Lawrence, KS	8	<$1M	
			8	<$1M	
Louisiana					
	Advanced Composite Manufacturing (ACM)	Broussard, LA	10	$1.2M	
			10	$1.2M	
Maine					
	Sonic Blue Aerospace, Inc.	Portland, ME			
	Warrior (Aeromarine), Ltd.	Scarborough, ME			
Maryland					
	AAI	Hunt Valley, MD	900	$220M	USA, Romania, USN, USMC
	L-3 Com Aerosystems (BAI)	Easton, MD	30	$6M	USMC, USA, USN
	Proxy Aviation Systems	Germantown, MD	20	$1M	
	Brandebury Tool Co., Inc.	Gaithersburg, MD	5	$1M	
			967	$228.5M	
Massachusetts					
	Aerocopter, Inc.	Andover, MA	5	<$1M	
	Nascent Technology	Lexington, MA	4	<$1M	
	Tacshot	Cambridge, MA	2	<$1M	

State	Company	Location	Employees	Revenues	Customers
	Black Fly Helicopters, LLC	Danvers, MA	5	<$1M	
			16	<$1M	
Minnesota					
	Lockheed Martin MS2	Eagan, MN	11,000+		USAF
			11,000		
Mississippi					
	Northrop Grumman Corp.	Moss Point, MS	60		
	Air-O-Space (GB Technologies)	Picayune, MS	3		
	Aurora Flight Sciences	Starkville, MS	30		USA, Israel
			93		
Missouri					
	Boeing Aircraft Co. (McDonnell)	St. Louis, MO	17,000+		
			17,000+		
Nevada					
	Global Aerial Surveillance	Las Vegas, NV		<$1M	
	GSE, Inc.	Incline Village, NV		<$1M	
	Lew Aerospace	Las Vegas, NV	8	<$1M	
			8	<$1M	
New Jersey					
	Aereon Corp.	Princeton, NJ			
			0		
New Mexico					
	Applied Research Associates, Inc. (ARA)	Albuquerque, NM			
	Honeywell Defense Avionics Systems	Albuquerque, NM	1,000		
	Romotech Aerospace-NM (New Mexico Aerodyne)	Alamogordo, NM	500	<$1M	
			1,500	<$1M	

State	Company	Location	Employees	Revenues	Customers
New York					
	BAE Systems Platform Solutions	Johnson City, NY	6,400	$1,152M	
	Sikorsky (Schweizer)	Big Flats, NY	475		
			6,875	$1,152M	
North Carolina					
	Carolina Unmanned Vehicles, Inc.	Raleigh, NC	2	<$1M	
	Innovation Robotics	Greensboro, NC	2	<$1M	
			4	<$1M	
Ohio					
	Theiss Aviation	Salem, OH	8		USN/NRL, ONR, USAF
			8		
Oklahoma					
	Republic Aerospace Corp.	Duncan, OK			
	Airborne Technology, Inc.	Catoosa, OK			
Oregon					
	Oregon Iron Works, Inc.	Clackamas, OR	400		
			400		
Pennsylvania					
	Dragon Fly Pictures, Inc.	Essington, PA	8	<$1M	DARPA
	Piasecki Aircraft Corporation	Essington, PA	35	$2M	USN
	Navmar Applied Sciences Corp.	Chester, PA			
			43	$2M	
South Carolina					
	Rotomotion	Charleston, SC	8	$1M	
			8	$1M	

State	Company	Location	Employees	Revenues	Customers
Tennessee					
	Accurate Automation Corp.	Chattanooga, TN	35	$7M	NASA, USAF
			35	$7M	
Texas					
	Bell Textron Inc.	Ft. Worth, TX	57,000	$9,300M	
	DRS Unmanned Technologies	Mineral Wells, TX	30		USA, USN, USAF, USG
	Geneva Aerospace Inc.	Carrollton, TX	35	$8M	USAF, DARPA, USN
	Mission Technologies, Inc. (MiTex)	San Antonio, TX	20		USA
	Prescott Products	Lockhart, TX	5	<$1M	
	Vought Corp.	Dallas, TX	6000	$1,300M	
	GB Technologies	Houston, TX	200+	$20M	
Utah					
	Reconisys, LLC	West Jordan, UT			
	Procerus Technologies	Vineyard, UT			
Virginia					
	Allied Aerospace	Newport News, VA	850		USN
	Aurora Flight Sciences Corporation	Manassas, VA	300	$5M	NASA, USAF
	Schiebel Technology, Inc.	Warrenton, VA	100	$7M	USA, Egypt
	Avid, LLC	Blacksburg, VA	2	<$1M	
	NC2, Inc.	Lorton, VA	1	<$1M	
	Victory Systems, LLC	Woodbridge, VA	6	<$1M	
			1,259	$12M	
Washington					
	The Boeing Co.	Seattle, WA	230,000	$36.5M	DARPA, USN, NASA
	Dara Aviation	Woodinville, WA	8	<$1M	Canada

State	Company	Location	Employees	Revenues	Customers
	The Insitu Group	Bingen, WA	160	$7M	USMC, Fugro Airborne Surveys
			230,168	$43.5M	
West Virginia					
	Aurora Flight Sciences	Bridgeport, WV	90	$10M	
			90	$10M	
Totals			63,090	$10,628M	

Appendix B: Sensor Manufacturers.

State	Company	Location	Employees	Revenues	Revenues
California					
	Raytheon/Hughes	El Segundo			
	FSI/Indigo	Goleta		$78M	$78M
	L-3 Wescam	Healdsburg			
				$78M	$78M
Florida					
	DRS EO System Group	Palm Bay			
Illinois					
	Recon Optical, Inc	Barrington			
	Northrop Grumman ES	Rolling Meadows			
Maryland					
	L-3 BAI Aerosystems	Easton			
Massachusetts					
	FSI/Inframetrics	North Billerica	200	$54M	$54M
			200	$54M	$54M
Oregon					
	FLIR Systems, Inc.	Wilsonville	780	$483M	$483M
			780	$483M	$483M
Texas					
	Raytheon S&A Systems	McKinney			

Appendix C: Engine Manufacturers.

State	Company	Location
Arizona		
	Honeywell Aerospace	Phoenix
California		
	Herbrandson	Lawndale
Florida		
	Sensenich Wood Propeller Co.	Plant City
Indiana		
	Rolls Royce/Allison	Indianapolis
Pennsylvania		
	USQ Engines	Mechanicsburg

Appendix D: Data Links.

State	Company	Location	Employees	Revenues
California				
	Cohu/Broadcast Microwave Services, Inc.	San Diego		
	NS Microwave, Inc.	Spring Valley		
Iowa				
	Rockwell Collins	Cedar Rapids		
Nevada				
	Sierra Nevada Corp.	Sparks	425	$120M
			425	$120M
Utah				
	L-3 Communications	Salt Lake City	1700	
			1700	
Virginia				
	Raytheon C3&IS	Falls Church		