Kodiak Launch Complex (KLC)
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Alaska Orbital Launch Complex (AOLC)
History and Lessons

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KLC is in a remote location with unique transportation, environmental, and operational challenges. Using the concepts, planning, evolution, design and construction of the vision once known as the Alaska Orbital Launch Complex (AOLC), this paper will address the development of an orbital launch complex, from scratch, utilizing commercial practices. As existing launch sites consider expansion and as totally new launch sites are anticipated, it is appropriate to examine the KLC experience.

BRPH Architects - Engineers, Inc. was formed in 1964 by engineers working at Cape Canaveral in the early days of developing the United States Space Launch Capability Infrastructure. It has remained continuously active in all aspects of engineering design and construction at Cape Canaveral Air Force Station and John F. Kennedy Space Center (KSC) since then. It has also provided and continues to provide aerospace facilities design and construction services at Vandenberg Air Force Base (VAFB), California, Wallops Flight Facility / Virginia Space Flight Center, Virginia, and around the world. The company has been instrumental in the development of commercially owned and operated aerospace endeavors over the last 20 years. It was the designer/builder of Astrotech International's first commercial Payload Processing Facility near KSC and on VAFB. It also designed and provided construction support for Launch Pad Zero A (LP-0A) for EER Systems and Launch Pad Zero B (LP-0B) for the Virginia Commercial Space Flight Authority (VCSFA) at Wallops Island, Virginia. All of these commercial projects used BRPH's years of experience and "Lessons Learned" to provide high quality, efficient, functional and innovative facilities at low first cost. It was only natural that in 1993 the Alaska Aerospace Development Corporation (AADC) selected BRPH as the Architect-Engineer and, later, the Construction Contract Administrator for the Kodiak Launch Complex (KLC).

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I. Introduction

Kodiak Island is off the southern coast of the United States state of Alaska, separated from the Alaska mainland by the Shelikof Strait (40 to 48 kilometers 25 to 30 statute miles) (Fig. 1). The main city, Kodiak, is approximately 400 km (250 air miles) from the mainland city of Anchorage. The largest island in the Kodiak Archipelago, Kodiak Island is the second largest island in the United States and the 80th largest island in the world, with an area of 9,311 km^2 (3,595 sq. mi). It is 160 km (100 miles) long and in width ranges from 16 to 96 km (10 to 60 miles). Kodiak Island is mountainous and heavily forested in the north and east, but fairly treeless on the south. The island has many deep, ice-free bays that provide sheltered anchorages for boats. The southwestern two-thirds of the island, like much of the Kodiak Archipelago, is part of Kodiak National Wildlife Refuge. Kodiak is home to much wildlife, including the very large Kodiak Brown bear.

Figure 1. Map – Kodiak Island, Alaska, United States

Kodiak is also home to the Kodiak Launch Complex (KLC) which was originally known as the Alaska Orbital Launch Complex (AOLC). KLC was the nation's first commercial spaceport not collocated on a federal range. About 44 road miles south of the city of Kodiak at Narrow Cape, the spaceport is state-of-the-industry.

Development of KLC began in 1991 when the Alaska State Legislature established the Alaska Aerospace Development Corporation (AADC) as a state owned corporation to promote development of an aerospace industry in the state. Construction began in January, 1998, the first sub-orbital launch (from temporary accommodations) was in August 1998, and the first orbital launch was in September, 2001 (Fig. 2).

This paper chronicles the design and construction of KLC bringing its facilities to the initial launch capability from the standpoint of the primary contractor, BRPH Architects-Engineers, Inc. (BRPH). Descriptions and narrative are as of that initial capability with KLC's five primary facilities. Since that time there have been many additions, upgrades and changes to the complex. These include changing the Alaska Aerospace Development Corporation name to that of the Alaska Aerospace Corporation (AAC) in 2009 to recognize the its growth and successful operation. (This paper refers to AADC because that was the corporation's designation during the subject period).

Additional land has been secured, additional facilities have been built and additional launches have been performed as Kodiak secured itself as a successful commercial spaceport. All these changes are important but focus on the initial effort is useful and is solely the topic of this paper.

Figure 2. Lift Off from Launch Pad 1

II. Kodiak Overview

BRPH has been instrumental in the development of commercially owned and operated aerospace endeavors. BRPH was the designer and builder of Astrotech International's first commercial Payload Processing Facility near KSC and on VAFB. It also designed and provided construction support for Launch Pad Zero A (LP-0A) for EER Systems and Launch Pad Zero B (LP-0B) for the Virginia Commercial Space Flight Authority (VCSFA) at WFF/VSFC, Wallops Island, Virginia. All of these commercial projects used BRPH's years of experience and "Lesson Learned" to provide high quality, efficient, functional and innovative facilities at low first cost. Based upon the flexibility and applicability of the Wallops concepts and upon the corporation’s ability to control costs, the Alaska Aerospace Development Corporation (AADC) selected BRPH in 1993 as the Architect-Engineer and, later, the Construction Contract Administrator for the Kodiak Launch Complex (KLC). Thus, BRPH has intimate familiarity with the concepts, planning, evolution, design and construction of the vision once known as the Alaska Orbital Launch Complex (AOLC). It is currently supporting the AAC in assessment, preliminary studies, and cost analysis of options to expand the Kodiak capabilities to medium size launch vehicles.

A. General Description of Complex and Capabilities

The Kodiak Launch Complex (KLC) is a rocket launch complex owned by the Alaska Aerospace Development Corporation (AADC), an Agency of the State of Alaska. Located at Narrow Cape, Kodiak Island, Alaska, KLC is situated on 3,200 acres of state owned land (with authority to limit public access to an additional 7,000 acres to assure public safety and security). KLC was constructed to provide checkout and launch facilities to any private or public organization desiring to launch suitably sized launch vehicles. It is the nation’s first full service commercial spaceport that was not collocated on a federal launch range. Flight operations began in 1998.

Launch vehicles and payloads come to KLC via sea and air depending on size and customer needs. Ports of entry include the regional airport, which is collocated with the U.S. Coast Guard Base near the town of Kodiak, and the LASH Dock, a marine terminal located adjacent to the U.S. Coast Guard Base. Transport from the port of entry is by highway to KLC.

KLC is the nation’s only high latitude full service spaceport. It features all indoor, all weather, processing and was designed specifically to provide optimal support for space launches to polar orbit, including circular and highly elliptical Molniya and Tundra orbits. KLC offers unrestricted down range launch azimuths ranging from 110° to 220°, and is the only U.S. facility that can launch high inclination (63.4°) missions without land over-flight and the requirement to resort to energy consuming dog leg flight segments (Fig. 3).

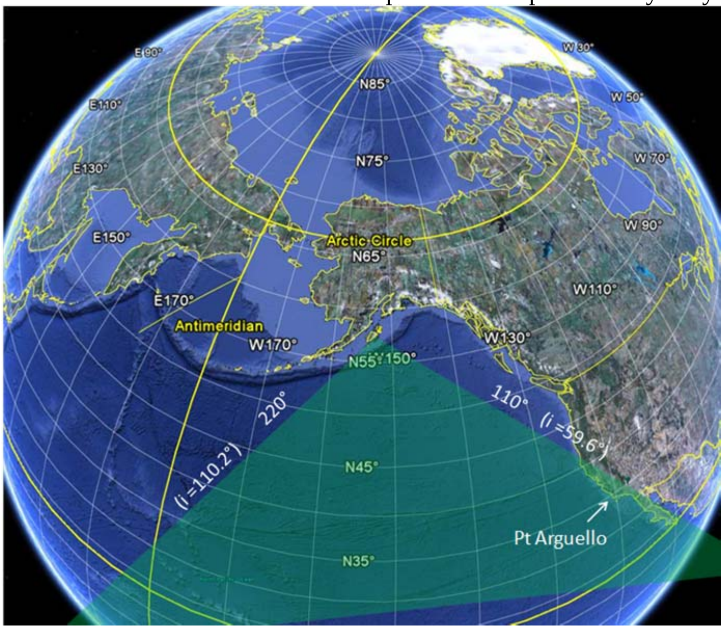


Figure 3. KLC offers unrestricted down range launch azimuths ranging from 110° to 220°

B. Alaska Aerospace Development Corporation (AADC)

The Alaska Aerospace Development Corporation (AADC) is an agency of the State of Alaska, established in 1991 by the legislature to promote development of the aerospace industry in Alaska. AADC is a public corporation located for administrative purposes within the Department of Commerce and Economic Development (DCED) and is affiliated with the University of Alaska (UA). AADC’s budget is subject to legislative appropriation and is funded from interest earned by the Alaska Science & Technology Foundation (ASTF) on its endowment as well as corporate receipts. Policy direction is provided by an appointive Board of Directors. Management is provided by an Executive Director and a small administrative staff located in Anchorage and a Site Manager and Operations and Management Team located on Kodiak.

AADC's core business area is space launch. It developed, owns, and operates the Kodiak Launch Complex (Fig. 4), a state-of-the-industry spaceport on Kodiak Island, Alaska, which provides access to space for commercial and government interests. The corporation's charter encompasses more than space launch, and it participates in other aerospace fields as well. The AADC charges a fee for the use of its facilities and for any services it provides.

Figure 4. Kodiak Launch Complex from the Air

Figure 5. LP-1, LP-2, SCAT and IPF

C. KLC - Primary Facilities and Structures

The KLC consists of five primary facilities and a number of support facilities, all located on 3200 acres of land permanently leased from the State of Alaska. The complex was designed for Castor 120 based solid propellant launch vehicles up to Athena III and can also accommodate Minute Man II vehicles with Class 1.1 propellants. The spaceport, like all U.S. west coast facilities, sits on the seismically active Pacific Rim, and all structures and components are designed to exceed applicable design criteria for seismically active zones.

Primary facilities and structures consist of the Launch Pad (LP-1 and LP-2), Launch Operations Control and Management Center (LCC), Payload Processing Facility (PPF), Integration and Processing Facility (IPF), and Spacecraft and Assemblies Transfer Building (SCAT) (Fig. 5).

1. Orbital Launch Pad

The KLC Orbital Launch Pad (LP-1) and Launch Service Structure (Fig. 6) provide protection and access to the launch vehicle stack for final assembly and checkout. It supports all weather processing for flight including placement on the stool, vertical motor and payload integration, and final testing. A 172.5-foot (ft.) tall steel frame facility provides vehicle/payload integration, testing, and launch consisting of a fixed service structure, rotating service structure, and a rotating service door, the launch equipment vault, along with the flame trench and pad apron. The environmentally conditioned facility functions as the gantry at LP-1. Features include:

- 75 ton bridge crane with 157 ft. hook height
- Four work platforms adjustable in height by 1 ft. increments
- Custom fitted work platform inserts accommodate vehicles to 16 ft. in diameter
- Flame trench rated to 1.1 million pounds of thrust

Figure 6. Orbital Launch Pad (LP-1)

KLC Launch Pad 2 (LP-2) LP 2 supports the launch of long range ballistic target missiles and other missiles from a flat concrete pad. It provides sub-orbital launch capability and protection for sub-orbital launch vehicles during assembly, check-out, and other pre-launch operations. LP-2 consists of the Pad Apron, an at-grade Launch Pedestal, the Space Craft and Assemblies Transfer (SCAT) building, and the Launch Equipment Building (LEB).

Launch Pad 2 began as a temporary capability to permit sub-orbital launches from KLC while the permanent lower range (IPF, SCAT and LP-1) were under construction. Two successful launches demonstrated the functionality, flexibility, and usefulness of LP-2. LP-2 has been upgraded to an operational pad for this reason. LP-2 provides a concrete apron for staging and check-out of the launch vehicle. An underground 8-in. diameter conduit provides a protected path for umbilical cables between the LEB and the launch vehicle. Foundations and tie-downs are provided at LP-2 so that the SCAT may be positioned and anchored over LP-2 affording environmental protection. The SCAT was originally intended to serve as a rolling garage to provide shelter from the weather when transferring spacecraft and assemblies from the IPF to LP-l. The second sub-orbital launch from KLC demonstrated the SCAT's usefulness as a processing facility.

2. Launch Operations Control and Management Center (LCC)

Figure 7. Launch Control Center (LCC)

The Launch Control Center (LCC) (Fig. 7) is the administrative and engineering support facility for the Kodiak Launch Complex. As such, it is the primary communications and data center for range functions and is connected to the other facilities by the communications backbone. A 14,000 square foot single-story, multi-purpose facility provides launch control, range management, and administration functions as well as workspaces and shops for visiting launcher and payload providers. Located approximately two statute miles away from the Launch Pad, the LCC lies outside the Payload Processing Facility (PPF) safety distance separation requirements, thus ensuring the safety of launch personnel even during hazardous vehicle processing operations. In addition to housing the Mission Control Room, the LCC houses all administrative and engineering support personnel, offices, general labs, rest rooms, showers, and a break room. The LCC provides both private office and open space areas for the facility users.

3. Payload Processing Facility (PPF)

This facility (Fig. 8) provides a class 100,000 clean facility for the checkout and fueling of spacecraft and supports the staging, processing, integration, inspection, and encapsulation of payloads.

The Payload Processing Facility (PPF) is geographically located so that hazardous operations do not impact operations at the LCC, the IPF, or LP-l. The PPF lies approximately 0.8 miles from the LCC and 1.1 miles from LP-l. The PPF provides high bay work space for space craft processing and encapsulation in a clean work area (CWA). Adjacent low bay space provides supporting functions. The overall facility is approximately 10,570 ft^2. The design provides for future expansion of both high bay and low bay space.

Figure 8. Payload Processing Facility

The PPF high bay structure is approximately 66 ft. high and provides approximately 4,800 ft^2 of floor space. It consists of an airlock with a roll-up door leading into the Payload Processing Bay. Access to the Airlock is through a pair of back-to-back roll-up doors. Space in the high bay airlock is sufficient to receive, inspect, clean, and stage the spacecraft and payload fairing. The low bay equipment airlock gives direct access to the Payload Processing Area for ground support equipment and fuel carts without violating the CWA. A 15-ton bridge crane serves both the Airlock and the Processing Bay. The Control Room affords a full view of the processing area.

Spacecraft are received in the PPF, processed, fueled, checked out, mated to the interface adapter that will attach the spacecraft to the launch vehicle and encapsulated in the flight fairing. The commercial practice of performing spacecraft encapsulation in the PPF prior to moving to the launch pad allows for parallel operations at KLC. Thus launch site user s minimize time on pad.

Payload Processing Facility Features include:

- Class 10,000 clean room operating environment that is capable of class 100,000 operations
- Two 40 ft. by 60 ft. work bays separated by a Megadoor
- 15 ton bridge crane having 50 ft. of hook height
- 30 ft. by 32 ft. equipment airlock
- Air shower with air lock
- Hydrazine fueling capability with spill sump, Hazardous Vent Detection System (HVDS), fire alarm, and Closed Circuit Television (CCTV) coverage

4. Integration and Processing Facility (IPF)

The Integration and Processing Facility (IPF) (Fig. 9) is a high bay receiving, staging, integration and checkout facility having interface capability with the Spacecraft and Assemblies Transfer (SCAT) facilities. This 7,100 square foot steel frame structure provides a 50 ft. x 100 ft. motor and stage processing bay designed for vehicles requiring horizontal processing or for any other covered, horizontal operations. The IPF provides space for receipt, processing, integration, and checkout of solid rocket (propellant) motors (SRM), equipment sections, and other hardware prior to roll over to the launch pad.

Figure 9. Integration and Processing

The IPF lies near the LP-I service structure but is sufficient distance from all other facilities to allow for parallel hazardous operations. The IPF is sited so that certain class motors or small ordnance can be processed within the building. Support operations can also take place at the IPF while certain class motors are present at LP-l. An equipment airlock provides for controlled entry into the High Bay without opening the large roll-up doors and pro vides storage space for test hardware or small flight components. Space is provided for processing checkout and integration of launch vehicle stages, test consoles, flight kits, vehicle close-outs, equipment storage, and other vehicle horizontal processing operations. The installation of initiators, ordnance safe and arm systems, and performance of continuity checks can be carried out in the IPF. Components in processing are connected to the facility grounding and counterpoise system at all times during operations.

Integration Processing Facility features include:

- 55 ft. by 100 ft. environmentally conditioned work area
- 25 ton bridge crane having 40 ft. of hook height
- Office for customer test instrumentation and records

5. Spacecraft and Assemblies Transfer (SCAT)

This 3,500 SF steel frame shelter (Fig. 10) is unique in design, as it rolls between the IPF and the launch pad. The shelter, mounted on rails, provides a conditioned transfer area and protection from the environment for the vehicle, payload, and components. It is a self-contained, environmentally controlled structure for transporting launch vehicle and payload assemblies from the IPF to the launch pad service structure.

The SCAT facility is a mobile self-contained structure that is used to transfer launch vehicle stages, spacecraft, flight hardware and general support equipment from the IPF to the LP-1 Service Structure or to the Sub-Orbital Launch Pad (LP-2). The SCAT facility provides environmental protection to launch vehicle components during transfer from the IPF to the launch pad. It is a shell structure (approximately 50 ft. wide, 70 ft. in length, and 50 ft. high to the eave) that uses an external motive force for travel.

Figure 10. Spacecraft and Assemblies Transfer (SCAT)

The SCAT's normal stow position is at the sub-orbital launch pad, LP-2, about 100 ft. east of the IPF. During operations, the SCAT can be rolled down the rail to the IPF or Launch Pad 1 (LP-I) from the stow position at LP-2. Concrete slabs are provided at the IPF, at LP-2, and at the Launch Service Structure (LSS) for transferring flight hardware when the SCAT is parked. Otherwise, the SCAT travels over an asphalt road between the two structures via a heavy-load roller system (Hillman rollers) with runway rails anchored to concrete grade beams. When parked next to either the IPF or LP-l Service Structure, the SCAT becomes an integral part of that facility. A pair of roll-up doors at the IPF end of the SCAT interfaces with a pair of roll-up doors on the IPF. A rollup door at the LP-l Service Structure end of the SCAT allows movement of tall vehicle components from the SCAT into the Service Structure. At both of these park sites, the SCAT work area is a reinforced concrete slab. The launch components to be moved are rolled from the IPF into the SCAT on dollies or trailers (i.e., component transporters, or CT). All items transferred in the SCAT are positioned in their normal transporting/assembly dollies / carts and are locked into place within the SCAT with hard stays. A flexible cable assembly, Figure 8-2, connects the IPF facility power to the SCAT, providing temporary power to operate the overhead roll-up doors, lights, humidifier, and unit heaters. Heaters thermally condition the interior space to avoid cold soaking during the unpowered, unheated transfer to LP-2. In this way, the internal temperature can be controlled prior to transferring launch vehicle stages, spacecraft, flight hardware, general support equipment, transporters, and shipping containers to the LP-l Service Structure in all weather conditions. If operations are lengthy, the launch vehicle, flight hardware, and other components, can be wrapped in insulation blankets for the unheated transfer to the launch pad because the SCAT is not heated during the transfer. Once temporary power disconnects, the SCAT is moved to the launch pad where power can be restored by connection to the launch service structure (LSS).

The SCAT can also be used as an environmental shelter at the suborbital launch pad. The flexible power cable from the IPF is long enough to reach the LP-2 area and allows final integration and testing of sub-orbital vehicles prior to launching from a sub-orbital launch stool.

SCAT features include

- Two 40 ft. by 60 ft. work bays separated by a Megadoor
- 15 ton bridge crane having 50 ft. of hook height

D. Supporting Systems

The complex (Fig. 11) is connected by operational intercom, telephone, data, closed circuit television and paging and areas warning systems. Communication to the outside world is by a 9-meter satellite ground station down-linking to Anchorage and Seattle, and connecting to ground communications at those points. Public electrical power sources, backed-up by generators floating on line provide power throughout the complex. Potable and fire water, local sanitary sewers and paved roads complete the complex.

The AADC is organized to provide or procure all services necessary for a User to have a successful operation at KLC. Users are provided with:

a. Fire Protection
b. Routine Site Security
c. Building and Facility Maintenance
d. Water Service
e. Sanitary Sewerage
f. Use of facilities as required for the operation, including associated furniture, cranes, and equipment.
g. AADC owned Computer Maintenance
h. Site Maintenance

The AADC arranges for other services as required including:

a. Telephone and all off-site communications
b. Clerical and office support
c. Janitorial (other than routine)
d. Reconfiguration of Spaceport Control System and cabling

Site security is provided by fencing individual facilities such as the LCC, PPF, and the lower range, which consists of the launch pad, IPF, and SCAT area. Facility fences are 7-foot high, chain link, grounded, with 3 strands of barbed wire. Personnel gates have hardware which will allow panic exit but no entry. All building entries are controlled by cipher locks. There is no overall area fence; however, barricades are established at the main KLC entry point near the LCC when hazardous operations require it. Guard service is the responsibility of the User.

KLC provides for the removal of non-hazardous refuse and waste, limited to routine materials generated from normal operations. Major packing materials, shipping containers, and construction refuse are the User's responsibility. Hazardous materials, including hypergolic fuels and contaminated wash water are the responsibility of the User. However, KLC will arrange for proper disposition of these materials.

The KLC Configuration Control System is designed to manage the exact configuration of KLC facilities and systems. It is generally permissible, with approval, for KLC facilities to be modified to support a particular program or mission. However, the Configuration Control System will require full documentation of all such modifications and will prescribe such approvals and ultimate disposition of such modifications as required.

Figure 11. KLC Launch Pad Area

III. Kodiak Development

A. Concept Development

BRPH has worked at the Kodiak Launch Complex (KLC) since the project's inception twenty years ago. BRPH assisted Alaska Aerospace Corporation (AAC) in conception, site selection, layout and master planning of KLC, as well as providing design, and construction administration.

The site selection process began with investigation of the Poker Flat Research Range, Alaska in October 1993. The search spread to several potential locations across the state. The search cumulated with visits to Cape Grevelle and Narrow Cape on Kodiak Island on January 30, 1994. Kodiak, with its deep water port, airport capable of receiving military transport aircraft, significant existing infrastructure in the town of Kodiak, the largest U.S. Coast Guard Base in the world, and the unsurpassed downrange corridor from 64 degrees posigrade to 64 degrees retrograde made Narrow Cape the best selection.

B. Detailed Design

1994 was an eventful year for Kodiak development. Design began in earnest building upon the stepping stone concepts of the Grant Proposals. The designer prepared an extensive questionnaire and sent it to all known potential users of the planned complex. The questionnaire sought user requirements. The intent was to gather specific requirements that could be rolled together into the design to create a generic facility capable of supporting a multitude of launch vehicles and missions, both orbital and sub-orbital. The construction administrator prepared statements of work for and supported AADC in the selection of contractors for professional land surveying and geotechnical investigations. The concepts were developed into preliminary designs. All major structural, mechanical, electrical, communications, site development, and ground safety systems were technically defined. A rough order of magnitude cost estimate was prepared and a preliminary engineering report was published.

Quantity Distance (Q/D) determinations were next necessary. Working with another AADC contractor, Research Triangle Institute (RTI), the two companies developed calculations and graphics presenting the explosion hazards possible at KLC due to the nature of the work to be there conducted. The information defines separation distances between facilities, known as Quantity Distance separation or Q/D. These are theoretical distances based upon experimentation that should provide safety to personnel in nearby facilities should a catastrophic event occur in another facility. The calculations and separations account for the hazards associated with both dramatic explosion released pressures and fragments and projectiles hurled about as the result of a catastrophic event.

The designer used the Q/D information to develop a Master Plan and locate the facilities safely in relation to each other and by function. This allows orderly expansion and future growth for administrative functions, payload hazardous processing functions, rocket booster processing, vehicle stacking/erection and launching.

The prime developer took a lead role in presenting the 35% design review in Washington, D.C. in September 1994. Another review was conducted in Washington in March 1996 when the design was 90% complete. Washington was selected (as opposed to Alaska) due to its proximity to the offices of potential users, customers, and regulators. Both reviews included attendees from NASA, the U.S. Air Force, U.S. Department of Transportation, U.S. Office of Technology Assessment, the major U.S. launch vehicle providers, national and international satellite providers, payload processing specialist, launch range safety experts, and other government, commercial, and international entities. The design and special features of each facility as well as the overall complex were presented in detail. There were open questions, comments, and discussion throughout each review. Input received from the attendees was incorporated into the design.

The development team met with many launch component, vehicle and launch service providers throughout the course of the design in order to keep current with their particular programs and assure that KLC would meet all of their basic needs and as many specific needs as possible within the generic concept and the construction budget.

The developer knew many of the potential users before design started and met others during the process. The developer maintained contact and good working relationships with these companies including Thiokol, Orbital Sciences Corporation (OSC), Lockheed Martin Astronautics (LMA), International Launch Systems (ILS), the Boeing Company and its McDonnell Douglas Corporation (MDC) subsidiary, the Multi-Service Launch System (MSLS) program office, NASA KSC and WFF, Coleman Research Corporation (CRC), Ball Aerospace, Research Triangle Institute (RTI), Universal Spacelines/Rocket Development Company, Beal Aerospace, E'-Prime Aerospace, and Command Control Technologies. The designer developed concepts for additional KLC launch pads to meet the specific needs of certain of these launchers and provided assessments to convert LP-1 to support liquid fuel and oxidizer boosters. Other high level studies examined the potential and logistics of building infrastructure to produce liquid and cryogenic propellants within the state of Alaska to better serve the aerospace community.

The architect provided all building code and life safety code analyses during design. They then prepared the building construction permit applications on behalf of AADC. The contractor responded to all questions from the State Fire Marshal's office (who is the State Building Official), and was able to obtain the necessary permits for these special purpose facilities. The process was not simple. The architect had to go to great lengths to help the State Building Official understand not only how the individual facilities were to be constructed, but also how they were to be operated. The many safety systems were described and defined and the interworkings of these systems complex wide were made clear. The toughest facility to permit was the launch service structure. Since building codes do not address launch pads and service structures, a "Modification of Permit" was filed. The developer arranged for the Building Official to tour an existing operational launch pad. The "Modification of Permit" was then obtained with incorporation of a few reasonable concessions to the Building Official.

The prime developer participated with AADC and other industry partners in preparing a request for funding through the FY94 Dual Use Grant Proposal administered by the U.S. Department of Defense (DOD). The developer provided facilities planning and conceptual floor plans for the complete KLC Initial Launch Capability (ILC). Budgetary cost estimates and technical write-ups for each facility were developed. AADC was then able to target specific facilities in the proposal. D.O.D. provided strong funding to fledgling spaceports at the existing Air Force ranges of CCAFS and VAFB but did grant AADC enough funds to proceed with KLC planning and design. The next year, the developer again supported AADC with drawings, estimates and technical writing during preparation of the FY95 Dual Use Grant Proposal. AADC was awarded additional funding.

Figure 12. Construction Becomes Weather Dependent

C. Construction

AADC selected BRPH as the Construction Contracts Administrator in 1997 once construction funding was secured. Construction began in January, 1998. The contractor administered the construction contract utilizing a highly skilled on-site staff. Four personnel were on-site throughout the heavy construction work. Three of them, the Project Manager, Construction Inspector, and Administrative Assistant were Alaska residents. The Inspector and Assistant were actually Kodiak residents. The fourth fulltime employee was a resident engineer from the home office residing in an apartment on Kodiak. This required an individual familiar with the design and intricacies of aerospace facilities. This position was on a continuing basis with the engineer being rotated in and out of the field office to provide expertise in the area of work in progress; a Civil Engineer for site work and utilities, a Structural Engineer for foundations and building erection, a Mechanical Engineer for building environmental systems and plumbing, and an Electrical Engineer for power, communications, and safety systems. The process was augmented with several inspections by a team of home office Engineers, Architect, and Project Manager who designed the facilities to assure compliance with the intent of the design.

The contractor also hired professional services from Alaska and Kodiak companies to provide quality control and specialized inspections. These included Kodiak Quality Control for soils and concrete testing, Materials Integrity for structural steel and welding inspection, USKH for roof installation investigations, and Sherwin

Williams for failed steel coating system inspection. The construction administrator also provided an engineer at the LP-1 service structure steel fabricator/detailers shop to expedite the shop drawing/fabrication process, and provided witness testing for the 15 ton, 25 ton, and 75 ton capacity KLC cranes, sending engineers to the crane manufacturer's facility for shop testing.

The construction administrator assisted AADC preparing construction bid documents, conducted pre-bid meetings with the contractors and responded to contractor questions during the bid process. This resulted in a three phase construction process. Phase 1 was defined for site preparation and utilities backbone. This work could be reasonably target to local/state contractors and industry. The Phase 1 contractor was selected in December 1997. A pre-construction conference was held with the contractor on Kodiak and construction began in January 1998. Phase 2 consisted of construction of all facilities and the launch pad deck (and below). This work would be harder for the local skill base and contractor capacity to perform. The Phase 2 contractor was awarded in April 1998.

Phase 3 was separated out of phase 2 due to budget control considerations and consisted of the LP-1 Service Structure (Fig. 12). The administrator conducted competitive negotiations with three contractors in September and October of 1998. The Phase 2 contractor provided the lowest price and was selected for the work. The first material orders for Phase 3 were placed in November 1998. This put the last major construction contract in place.

Figure 12. LP-1 Service Structure Construction

Site selection, planning, design, and construction management for KLC is not the full extent of BRPH's involvement and knowledge however. It provided a study of the roads and bridges between the town of Kodiak and KLC. Recommendations for bridge inspections and options for upgrading the road were presented. The developer also worked closely with (Alaska Department of Transportation and Public Facilities (ADOT & PF) on Kodiak and in Anchorage to assure that the site roads are safe. Further, the developer supported ADOT & PF for the design of spot improvements for the off-site roads.

The administrator also provided design-build procurements for AADC for implementation at KLC. Three examples of specialty systems so provided are the Operational Intercommunications System (OIS), Paging and Area Warning Systems (PAWS), and the Spaceport Control System (SCS). The prime developer prepared performance specifications and schematic drawings for the OIS and PAWS, contacted vendors of these specialty systems and then contracted with the vendors to furnish, check-out, program, and test these critical communications systems. The PAWS provides a wide area speaker system for complex wide paging, messaging, and area warning about weather, hazardous operations and other important events. The OIS provides point-to-point communications and monitoring of payload, launch vehicle, and launch processing. The prime developer also provided a performance specification (PS) for the SCS. The PS was then sent to potential KLC users for review and comment. Comments received were incorporated into the PS. Several potential vendors were interviewed and the work was competed among the best qualified. Proposals were received and evaluated by BRPH, AADC, and an aerospace industry expert contracted by BRPH for that purpose. The prime developer then signed a contract with the successful offeror to provide, factory test, install, site test, and provide operational training to KLC and user personnel. The developer conducted design reviews, equipment inspection, and witnessed the factory and site testing of the system. The SCS is primarily used to monitor the health of the launch vehicle, spacecraft, and spacecraft environmental control, provide the timing and countdown signal interface, monitor the launch countdown and telemetry data stream, verify that the vehicle is within the specified trajectory limits, and calculate and display instantaneous impact point (IIP) predictions should the vehicle have to be terminated in flight. The system also records the TM data, archives it, and can retrieve data from current or previous missions for analysis and/or comparison.

The developer also provided real time engineering to design and construct a "temporary" launch pad and "temporary" launch control center (TLCC). This was necessary to support the first two sub-orbital missions, which occurred during construction. These were the United States Air Force AIT-1 mission in 1998 and AIT-2 in 1999. Site preparation, tie-in of power and communications, including additional copper wire and fiber optics between the temporary pad and the TLCC, an auxiliary concrete launch pad, and a launch equipment building adjacent to the pad were designed and constructed with the help and cooperation of the Phase 1 contractor in less than 4 months. There was a subsequent design-build project converting the SCAT and this pad to a permanent launch area with enhanced capability including addition of a new bridge crane, additional power and additional communications to accommodate several different sub-orbital launch vehicles. This became LP-2 and has been the workhorse for KLC.

The prime developer was also an active participant in the Pathfinder Operations for the Payload Processing Facility and the main, orbital launch pad and service structure. This required working closely with the spacecraft provider, launch vehicle providers, and mission personnel as the spacecraft mock up, inert launch vehicle booster and other hardware were run through simulated processing and stacking operations. The contractor then supported AADC in design and installation of mission and vehicle ground support equipment and facility modifications for both orbital and sub-orbital missions.

The developer also prepared specialty documentation for AADC. This included a package of checklists to verify that the facilities and systems at KLC have been constructed in accordance with the intent of the drawings and specifications. A part of this effort included a matrix of testing and validation requirements to be signed off as complete and acceptable, and a brief narrative of additional test requirements to be developed; tests that users might expect to see as a condition of acceptability for mission use. The developer prepared a "first line of defense" Operations and Maintenance (O&M) manual. This document provides high level trouble shooting and maintenance information for most major systems at KLC into a single binder by culling the most important data from the dozens of volumes of O&M data provided by vendors and equipment manufacturers. Finally, the developer prepared the KLC Facility User's Manual. This document provides users an introduction to the ins and outs of KLC. It includes information on how to contract with AADC, how to get to Kodiak, local logistics, sections on each facility, and specific detailed information on systems and equipment. The text is supported with numerous facility and systems drawings and color photos.

IV. Conclusion

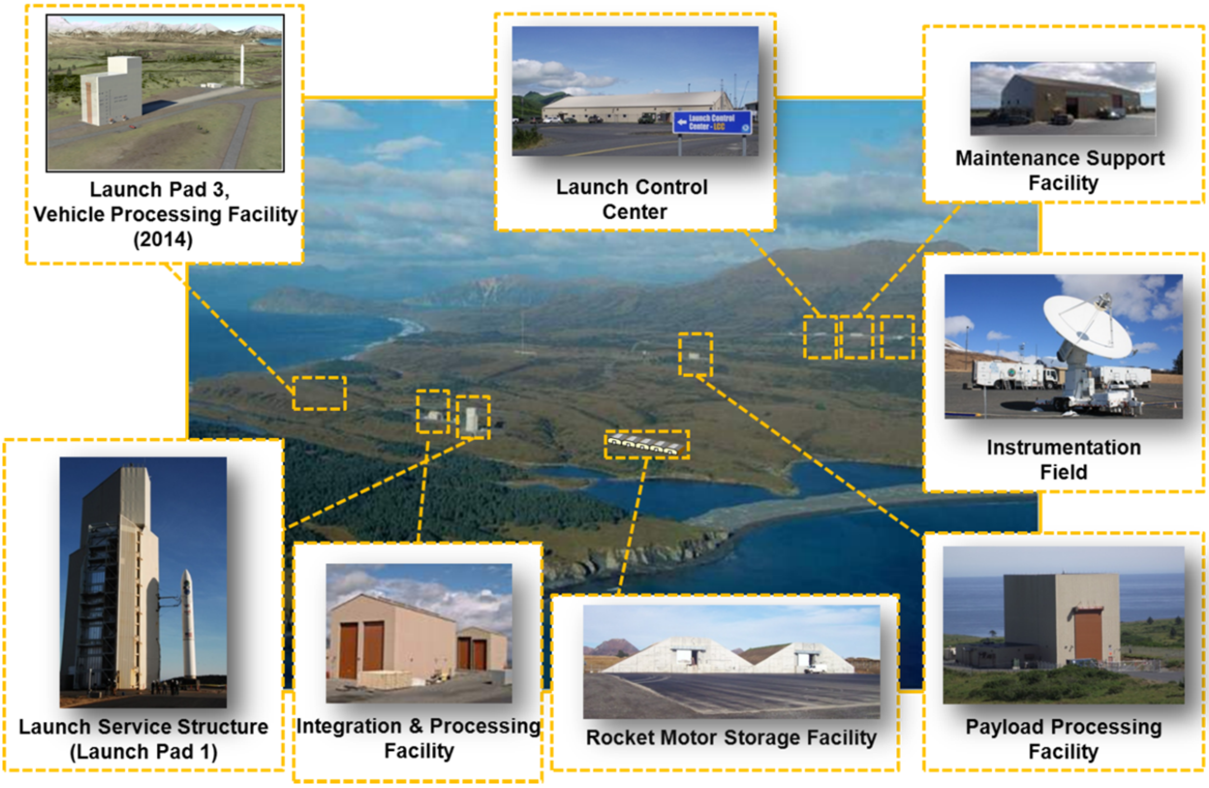
This paper has addressed the development of the initial launch capability (ILC) of the Kodiak Launch Complex and the involvement of the primary contractor BRPH. It is useful to understand the steps and actions necessary for that process.

Since ILC, there have been many complex additions and changes not discussed in this paper. These include:

- Maintenance and Support Facility
- Rocket Motor Storage Facility
- Antenna/instrumentation field
- Range safety and telemetry system (including GPS metric tracking)
- Weather forecast center
- On site lodge

These changes have expanded KLC's capabilities and usefulness as a launch site. Kodiak has launched sixteen orbital and suborbital missions, and placed ten satellites into orbit.

The latest change in KLC is the beginning of development of facilities to support medium size launchers including the Lockheed Martin Athena III and the Orbital Sciences Antares vehicles. Last year, Lockheed Martin announced its intent to offer Athena II services with a ride-share launch from Kodiak in late 2013 and that Kodiak would be the U.S. west coast home of the Athena III. The Athena III will be capable of launching satellites weighing 4,600 kg (10,150 lbs.) from KLC. The state budget includes $25 million to invest in the project ground facilitization. The state funding will now allow the project to move into the detailed engineering phase with construction anticipated to begin this summer. The first Athena III launch out of Kodiak is targeted for late 2014.



V. BRPH Overview

BRPH is a privately held company headquartered in Melbourne, Florida, United States with branch offices in Orland, Florida; West Palm Beach, Florida; Atlanta, Georgia; Charleston, South Carolina; and Washington, District of Columbia. Established in 1964, its first projects included providing engineering support to NASA and preparing a master plan of Kennedy Space Center. The company has grown steadily over the past 48 years, both in terms of staff and multidisciplinary experience, now serving aviation, education, energy, and local and federal government clients. Today, BRPH is an international planning, architecture and engineering, design and construction services firm with a staff of more than 180 professionals and revenues exceeding $45 million per year.

BRPH is a full-service, in-house firm with capabilities in planning; architecture; interior design; graphic design; civil/site, structural, mechanical, and electrical engineering; and construction management. BRPH also provides cost control/estimating and project scheduling and has an extensive quality control program. The company is organized according to market segments. Industry-specific teams are trained for their area of expertise, such as aerospace/aviation, commercial/industrial, and federal government. Each team includes registered architects and engineers in every discipline and includes drafters, and designers who have been trained for the various facility types in the markets they serve.

BRPH offers the expertise of a large firm, yet still provides the one-on-one relationship expected of small firm. Within the last five years, we have master planned and designed over 3,000,000 square feet of aerospace/aviation facilities. We also provide support to The Boeing Company, Lockheed Martin, United Launch Alliance, United Space Alliance, Space Gateway Support, Northrop Grumman Corporation, Embraer Aircraft, Gulfstream Aerospace, Harris Corporation, NASA and others in the study, design, and construction of facilities and ground support equipment. BRPH is committed to aiding space advancement through in-depth study, analysis, and design of some of the most technical processing facilities in existence. In addition to planning and design, our services include space planning, economic analyses, value engineering, cost estimating, building and site evaluation, development, and planning.

BRPH has been closely associated with spaceport development since the firm was started by engineers working at Cape Canaveral developing the United States Space Launch Capability Infrastructure. As neighbors of the Cape Canaveral Air Force Station (CCAFS) and Kennedy Space Center (KSC), we became participants in, as well as admirers of, the remarkable unfolding of U.S. space flight history. The company’s involvement includes the design or refurbishment of nearly every launch pad and aerospace facility at KSC, CCAFS, Patrick Air Force Base, Kodiak Island, and many at Vandenberg Air Force Base, Wallops Flight Facility / Virginia Space Flight Center (WFF / VSFC), Virginia, and down range facilities at Antigua and Ascension Islands. From the early years of rocket launches to the development of current sophisticated commercial launch complexes, our aerospace team has grown to include highly dedicated planners, engineers, architects, and technicians - experts in the field of launch facilities and systems and in the design of rocket and spacecraft processing. Today, BRPH is a leader in the design and development of infrastructure supporting commercial access to space.