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The Advanced Technology Development Center (ATDC)

Gregory R. Clements

NASA-Kennedy Space Center, YA-E6, KSC, FL 32899
Telephone 321-867-8992; E-mail Gregory.clements-1@ksc.nasa.gov

Abstract. NASA is building the Advanced Technology Development Center (ATDC) to provide a "national resource" for the research, development, demonstration, testing, and qualification of Spaceport and Range Technologies. The ATDC will be located at Space Launch Complex 20 (SLC-20) at Cape Canaveral Air Force Station (CCAFS) in Florida. SLC-20 currently provides a processing and launch capability for small-scale rockets; this capability will be augmented with additional ATDC facilities to provide a comprehensive and integrated in situ environment. Examples of Spaceport Technologies that will be supported by ATDC infrastructure include densified cryogenic systems, intelligent automated umbilicals, integrated vehicle health management systems, next-generation safety systems, and advanced range systems. The ATDC can be thought of as a prototype spaceport where industry, government, and academia, in partnership, can work together to improve safety of future space initiatives. The ATDC is being deployed in five separate phases. Major ATDC facilities will include a Liquid Oxygen Area (Phase 1); a Liquid Hydrogen Area, a Liquid Nitrogen Area, and a multipurpose Launch Mount (Phase 2); "Iron Rocket" Test Demonstrator (Phase 3); a Processing Facility with a Checkout and Control System (Phase 4); and Future Infrastructure Developments (Phase 5). Initial ATDC development will be completed in 2006.

ATDC PURPOSE

The nation currently needs a comprehensive, integrated, large-scale research, development, and test area for Spaceport Technologies. John F. Kennedy Space Center (KSC) has been given a leadership role in the development of Spaceport Technologies to lower the cost of access to space (Interagency Working Group, 2000). The Advanced Technology Development Center (ATDC) is a key project supporting KSC's evolution toward becoming a Spaceport Technology Center.

Some of the high costs currently associated with accessing space are due to the limited opportunities for infusing upgraded Spaceport Technologies. Thorough qualification testing is required before systems and processing can be operationally deployed. While some qualification can be performed in a laboratory environment, currently, full-scale qualification "in the elements" for many Spaceport Technologies can only be performed at an operational launch site. Since there is a risk that such full-scale qualification testing (especially test failures) may impact operations, this testing is rarely performed. Hence, operational Cape Canaveral Spaceport (consisting of KSC and Cape Canaveral Air Force Station [CCAFS]) launch sites have not received a great deal of upgrades in Spaceport Technology infrastructure.

Additional factors driving the cost of accessing space higher are the current labor-intensive vehicle and payload processing methodologies. Operational analysis has indicated that improvements and efficiencies could be implemented, including a wider use of autonomous systems, at nearly every KSC/CCAFS launch site. However, it is difficult to try new processing techniques for both Space Shuttle and Expendable Launch Vehicle (ELV) operations due to the stringent operational restrictions in place at operational launch sites. Again, the risk that performing uncertified processing tests (especially test failures) may impact operations prevents this testing from being performed.

Hence, with today's infrastructure, it is difficult to implement technology and techniques to improve the cost-effectiveness of current Space Shuttle/ELV or to greatly improve costs, safety, and processing as required for future vehicle and Spaceport Technology initiatives.

The ATDC will become not only a national resource, but also the world's premier site for full-scale research, development, demonstration, testing, and qualification of Spaceport Technologies. It will contain infrastructure that accurately mimics a launch environment, without many of the associated operational restrictions. Future vehicle (2nd generation, 3rd generation, etc.) and spaceport development initiatives can be developed at the ATDC in partnership with other KSC, State Government, Federal Government, and industry representatives. The ATDC will provide integrated capabilities not found at other NASA facilities or any other facilities in the United States.

Upgraded Spaceport Technologies and improved processing techniques that are intended for Space Shuttle and/or ELV operations can be developed and qualified at the ATDC with no risk to the operational infrastructure or capabilities of those programs.

Spaceport Technology projects and initiatives under development that show promise in a laboratory environment can be deployed and qualified at the ATDC under real-world conditions. The ATDC could perform a wide variety of processing or launch-related activities. Some of these activities include:

1. Performing repeated cryogenic testing using different processing methodologies and equipment to arrive at an optimum combination of efficiency, effectiveness, and safety.
2. Developing new vehicle-ground interface systems, such as umbilicals and hold-downs.
3. Developing improved launch acoustic protection systems.
4. Demonstrating the capability for spaceport infrastructure to rapidly reconfigure in support of differing processing requirements.
5. Demonstrating advanced work control system tools, such as "cradle-to-grave" requirements tracking that will greatly reduce the operational labor effort required to process payloads and vehicles.
6. Performing a processing operation with two differing system technologies side by side and comparing results.
7. Qualifying new integrated vehicle health management (IVHM) command and control systems.
8. Developing generic, versatile, containerized payload systems to reduce the cost of processing and integrating payloads.
9. Demonstrating the capabilities of Advanced Range Technologies by utilizing existing small-scale launch capabilities and facilities to fire sounding rockets in support of range development.

ATDC DETAILED OBJECTIVES

The ATDC will become a site capable of performing significant cryogenic research. The ATDC will be a major component of the long-range Cryogenics Testbed vision of collaboration among partners in research, industry, and training. Propellant densification has become a leading technology candidate for many of the new vehicle configurations in the planning stages. The ATDC will provide much-needed test capability for this technology as it continues to grow and mature.

The ATDC will also be a testbed for launch environment characterization and design development work. Projects demonstrating tools to predict the vibroacoustic environment of a spaceport and design mitigation techniques will be deployed and tested at the ATDC. Flame deflector designs, flame trench geometries, and facility layouts will be explored to optimize the spaceport design of the future.

The command and control and data collection systems employed at the ATDC will offer another development opportunity that can benefit future spaceports. Unlike currently deployed operational launch sites, different architectures can be tested in a realistic environment to determine the optimal future spaceport architecture. Health management and prognostic/informed maintenance systems can be tested for viability and reliability. New umbilicals, avionics systems, launch structures, and materials can be analyzed for suitability for future spaceport applications. Autonomous control architectures can be explored against real hardware and compared to operational launch sites to showcase just what benefits these technologies will have in the future.

Using the capabilities of the ATDC, new work control systems can be developed to automatically verify steps in a test procedure as hardware changes configuration and satisfies program-level requirements. It can transfer those verifications automatically to the requirements watchdog that verifies the vehicle is ready to fly, significantly reducing the amount of hardcopy paperwork required for Shuttle and ELV operations. The new paperless work control system will have documents with tutorial and online help features that can help a technician who is unsure of the procedure being used or is training to do the task for the first time. This will also help eliminate technician errors in the field.

Payload processing philosophies can also be explored at the ATDC. Generic, versatile, containerized payload systems have been sought after for many years. The ATDC can be used to develop and showcase examples of future implementations. Combining this effort with the Iron Rocket concept, vehicle interfaces for mounting and integration can be developed.

As the ATDC continues to grow, the vision is to move toward a generic launch complex that can handle multiple vehicle configurations easily. The Iron Rocket can be moved off the Launch Mount and replaced with a new vehicle configuration (multiple tanks, multiple stages, multiple payload configurations, etc.) with the same launch platform-to-pad infrastructure interfaces. This ties in the vehicle transportation development for a future system. Instead of a maintenance-intensive, tracked vehicle as is used at Launch Complex 39 (LC-39), a next-generation transporter can be developed similar to today's payload canister transporters that can operate on standard roads.

The ATDC also provides a place to develop next-generation range systems. SLC 20 already has a launch capability that can provide a platform for testing some of the new space-based and other advanced range technologies. Refer to the aerial photograph of SLC-20 below. As a reference point, the Command and Control Blockhouse is approximately 185 feet in diameter.

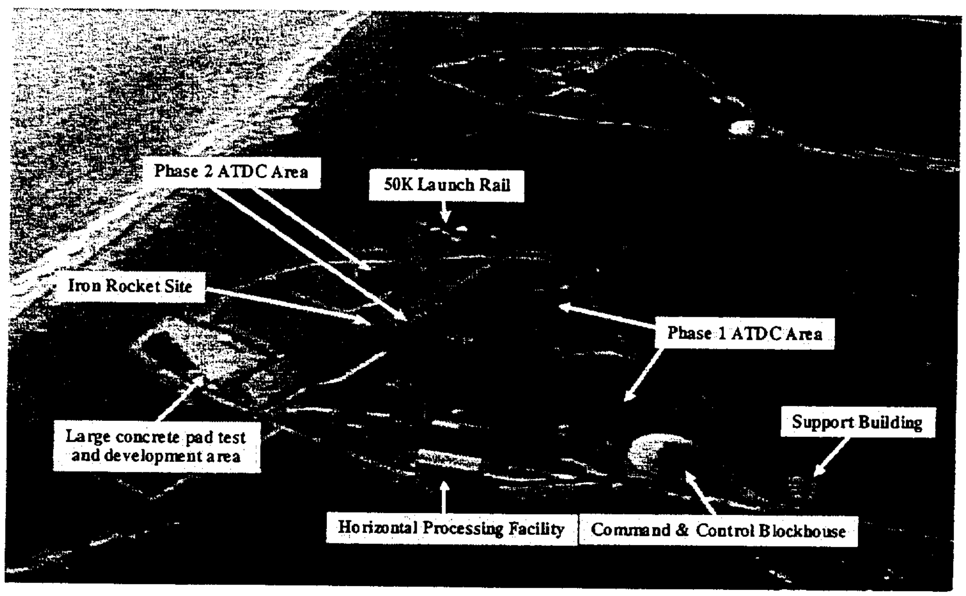

Figure 1. Aerial View of SLC-20.

In addition, the ATDC will become a place that can mimic most of the current and future operations of LC 39 at KSC and of the active Space Launch Complexes at CCAFS. These operations include vehicle checkout, payload integration to the vehicle, prelaunch processing, and the ground support systems of a launch facility.

The possibilities for the ATDC are endless. They touch on all disciplines at KSC and provide the Agency with an opportunity to bring designers and operators from multiple NASA Centers and the aerospace community together in one place to develop space access systems of the future. NASA-KSC will work hard to build these relationships with other NASA Centers, national laboratories, and contractors to build a more integrated development approach to meet the Agency goals of developing safer and cheaper access to space.

ATDC GOALS

The ATDC will help to fulfill goals of NASA to improve safety and to reduce costs to access space, as well as a goal of KSC to become the Spaceport Technology Center.

The primary goal of the ATDC is to provide, demonstrate, and test technologies and processes that will both increase the safety and reduce operations costs for preparing vehicles and payloads for space flight.

A complementary goal of the ATDC is to forge strategic partnerships with commercial companies engaged in the business of spaceports. NASA-industry partnerships will ensure the maximization of safety, expertise, innovation, and cost-effectiveness in developing the spaceports of tomorrow.

ATDC DEVELOPMENT APPROACH

This project presents a large development commitment by KSC and will require substantial operation and maintenance (O&M) once deployed. Where appropriate, reliability-centered maintenance (RCM) techniques will be used to identify the optimum maintenance required for each component of deployed infrastructure to defray and minimize the necessary O&M investment.

ATDC development costs will be primarily funded via a combination of NASA-KSC discretionary funding, NASA Spaceport and Range Technology Program funding, and other NASA program funding; partnership arrangements and fees from capital usage agreements that are developed with external organizations will also supplement funding. O&M costs will be funded via a combination of NASA-KSC funding and fees from capital usage agreements that are developed with other NASA and external organizations.

ATDC PROJECT PHASING

The five ATDC Project development phases are indicated below. These phases may overlap to maximize efficient usage of engineering, fabrication, and installation support.

ATDC Phase 1

This phase will develop a Liquid Oxygen (LO_2) Area (capacity 56,000 gallons LO_2), containing the appropriate infrastructure to safely provide, control, distribute, test, and remove LO_2. Supporting facility and ground support equipment (GSE) systems, such as a gaseous nitrogen (GN_2) purge capability, safety systems, instrumentation system, command and control system, closed-circuit cameras, and communications, will also be provided at this time. At the end of Phase 1, the ATDC will be able to qualify LO_2 cryogenic components and will support the Shuttle Program by performing LOX Pump qualification testing.

ATDC Phase 2

This phase will develop a Liquid Hydrogen (LH_2) Area (capacity 68,000 gallons LH_2), a Liquid Nitrogen (LN_2) Area (capacity 28,000 gallons LN_2), and a Launch Mount. As with the LO_2 Area, the appropriate supporting facility and GSE systems will be provided. At the end of Phase 2, the ATDC will be able to qualify LH_2 and LN_2 cryogenic components and could support companies developing 2nd generation vehicles by being able to support cryogenic loading testing on company-provided simulators and equipment.

ATDC Phase 3

This phase will develop a nonflight Iron Rocket and its Park Site. The Iron Rocket will contain avionics, instrumentation, and cryogenic tanks that can be loaded multiple times and used as a testbed to develop the next-generation cryogenic loading system. A permanent capability to create densified cryogenics (LO_2 and LH_2) will be added during this phase. The instrumentation systems initially deployed in the LO_2 Area, LH_2 Area, LN_2 Area, and Launch Mount will receive augmentation. At the end of Phase 3, the ATDC will facilitate research and development of umbilical systems, cryogenic loading concepts, and new instrumentation to provide more insightful information on system health and abnormal trending.

ATDC Phase 4

This phase will extend existing High-Pressure GN2 and Gaseous Helium (GHe) Pipelines to SLC 20 and add both a 2,000-square-foot Shop Facility and a 5,000-square-foot Processing Facility. The instrumentation, safety systems, and infrastructure deployed during Phases 1 through 3 will be augmented and will receive a "technology refresh." The Iron Rocket will grow in fidelity; avionics systems will be added to help develop new instrumentation to better understand the loading processes and leak isolation techniques. A Checkout and Control System, deployed in the Processing Facility, will provide new control software to reduce the workload of the operator. At the end of Phase 4, the ATDC could support multiple research, development, test, and qualification activities, with a relatively quick reconfiguration time.

ATDC Phase 5

This phase will expand the usage and capabilities of the ATDC to support emerging or commercially viable Spaceport Technologies. Extensive market research to reevaluate Spaceport Technologies will be performed prior to this phase. The ATDC will utilize "technology insertion" and feedback from both the market research and operational analysis to selectively upgrade infrastructure deployed in earlier phases. The Checkout and Control System, as well as the instrumentation, safety systems and infrastructure deployed during Phases 1 through 4, will be augmented with a "technology refresh." This phase has been budgeted to reflect 30 percent of the total cost of the ATDC infrastructure deployed in Phases 1 through 4. At the end of Phase 5, the ATDC will be a world-class site for developing, testing, and qualifying Spaceport Technologies. Figure 2 summarizes the development of all ATDC Phases.

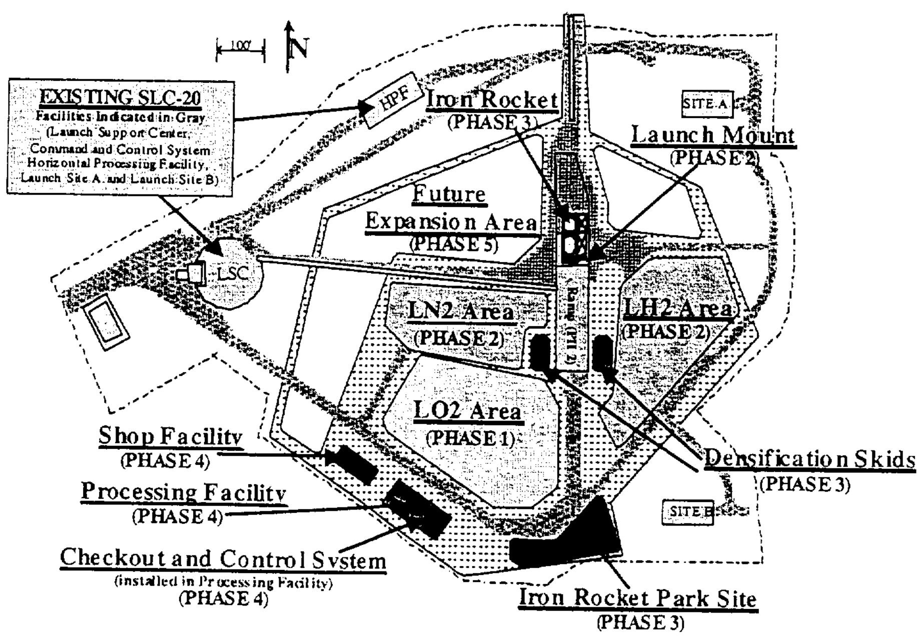

Figure 2. ATDC Phases.

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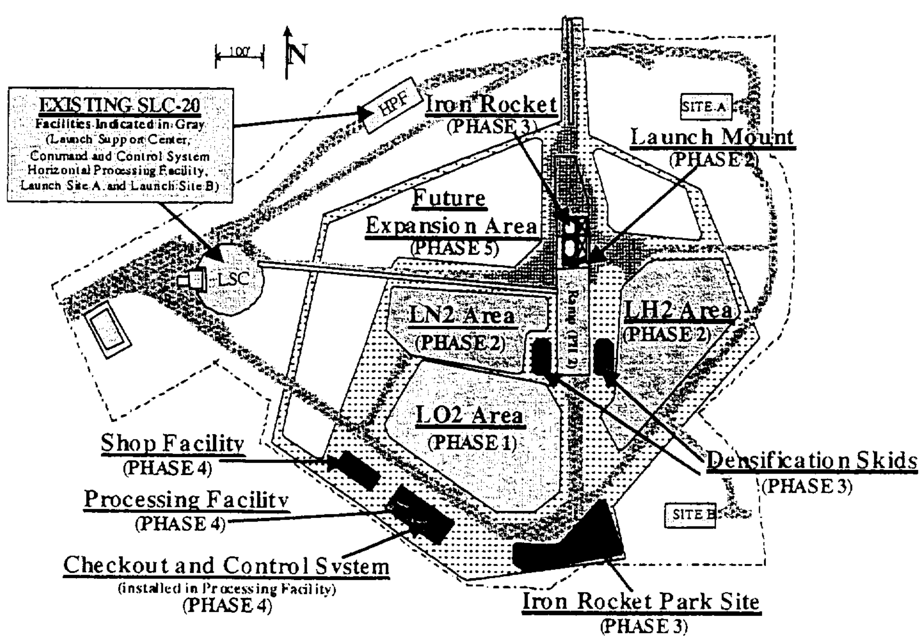

Figure 2. ATDC Phases.

PROJECT TIMEFRAME

The development of the ATDC will have a life cycle of six years concluding at the end of Government fiscal year (FY) 2006. After the end of the ATDC Project, the infrastructure that is in place would remain as a testbed area for future usage by NASA, Government, and contractor and industry organizations until it is decommissioned. Timelines for the five ATDC Development Phases are provided in Table 1. Each phase ends upon the turnover of infrastructure for operational usage.

TABLE 1. ATDC Timelines.

Phase	Start Date	End Date	Major Infrastructure Provided
1	Jan. 2001	May 2002	LO_2 Area
2	Jan. 2001	May 2002	LH_2 Area, LN_2 Area, Launch Mount
3	July 2002	June 2004	Iron Rocket, Cryogenic Densifiers
4	Oct. 2002	Aug. 2005	Processing Facility, Shop Facility, High-Pressure Pipelines, Checkout and Control System
5	Apr. 2004	Sept. 2006	Future Infrastructure Upgrades

CUSTOMER DEFINITION AND ADVOCACY

The ATDC will be capable of supporting the following customer bases:

- Cape Canaveral Spaceport (KSC/CCAFS) operational organizations
- New vehicle development (2nd generation, 3rd generation) organizations
- Spaceport development agencies
- NASA-KSC Spaceport Engineering and Technology (SE&T) Directorate
- Other NASA Centers, Department of Defense (DoD), and Government agencies
- Related industry vendors
- Commercial launch industries
- Academic research

The ATDC Project is developing multimedia aids (integrated web site at http://atdc.ksc.nasa.gov, brochures, collaborative engineering simulation, marketing tools) to ensure that the capabilities of the ATDC are well understood throughout the United States. In addition, ATDC personnel will be proactive in establishing and maintaining dialogue with this potential customer base.

Cape Canaveral Spaceport Operational Organizations

The KSC/CCAFS operational organizations (the Shuttle Processing, Payload Processing, and Expendable Launch Vehicle Processing organizations) can utilize ATDC Infrastructure to qualify new hardware components and technologies without introducing operational risk to these programs. As an example of this usage, the first phase of the ATDC, developing an LO_2 Area, will support the Shuttle Program in qualifying a new LOX Pump. For qualification, this pump is required to flow liquid oxygen at its rated capacity. The only location currently suited to perform this qualification is an operational launch site (such as the LC-39 pads), but there is a risk that a test failure/malfunction could damage operational infrastructure and impact launch operations. The ATDC removes this risk.

In addition, the ATDC is available to support the Shuttle, ELV, and Payloads organizations, thus improving the efficiency of existing KSC/CCAFS operational procedures by allowing "what if" scenario testing. An operating or test procedure can be rewritten and validated against actual launch site equipment at no operational risk to the program.

New Vehicle Development Organizations

The ATDC Infrastructure will also be made available to support initial demonstration, testing, and qualification of new vehicle development. This includes both Reusable Launch Vehicles (RLV's) and Expendable Launch Vehicles (ELV's).

NASA recently awarded an initiative to develop a 2nd generation RLV that is envisioned to reduce cost and increase safety by an order of magnitude of the 1st generation RLV (the Space Shuttle). The 2nd generation RLV contractors are evaluating the densified cryogenic capabilities of the ATDC. Multiple 2nd generation RLV contractors are currently planning to use the ATDC to support some of their proof-of-concept activities. The flexibility of the ATDC is well suited for supporting the 2nd Generation Program.

For ELV development, the ATDC could be used as a proving ground for related ELV technologies. By using the ATDC, ELV launch service providers could reduce their operational risk.

Spaceport Development Agencies

Various states have chartered Spaceport Development Agencies to study, develop, and deploy spaceports. Some of these agencies are starting from scratch, and most of these agencies are working with limited budgets. The ATDC can be utilized as a national resource to coordinate research, development, and testing to support these Spaceport Development Agencies.

In accordance with the "The Future Management and Use of the U.S. Space Launch Bases and Ranges," (Interagency Working Group, 2000) a nationwide Advanced Range Technology Working Group (ARTWG) was formed. The ARTWG includes both SE&T Directorate personnel and representatives from Spaceport Development Agencies. The ARTWG sessions will synergize range technology research and development. Some of this research may likely be conducted at the ATDC, and the ATDC will remain tuned into the ARTWG Proceedings.

In a similar manner, a nationwide Advanced Spaceport Technology Working Group (ASTWG) has been formed. The ASTWG includes both ATDC Project personnel and representatives from Spaceport Development Agencies. The ASTWG sessions will synergize development initiatives at the ATDC and maximize the benefits of its Spaceport Technology research.

Examples of potential ATDC activities that could be conducted in partnership with Spaceport Development Agencies include spaceport planning and conceptualization, operational processing, payload processing, environmental impacts, workforce development, and technology experiments.

NASA-KSC Spaceport Engineering and Technology Development

ATDC Infrastructure will be available in-house to field-test NASA-KSC Spaceport Engineering and Technology (SE&T) projects with commercial or operational potential.

The NASA SE&T Directorate contains a number of laboratories and testbed areas that are smaller in scale than the ATDC. For promising SE&T projects, small-scale laboratory qualification testing may not always be sufficient to fully qualify a Spaceport Technology; in these cases, the full-scale elements of a launch site would be required.

The ATDC Project will include funds to support the full-scale deployment of promising SE&T projects, as determined by organization priorities.

Other NASA Centers, DoD, and Government Agencies

Other NASA Centers, DoD, and other Government Agencies (e.g., the Federal Aviation Administration) will also stand to benefit from activities conducted at the ATDC. The ATDC can be utilized as a national resource; Spaceport Technology research can be coordinated in partnership to a maximum benefit for cost and information sharing. As with the Spaceport Development Agencies, the ASTWG and the ARTWG will synergize activities at the ATDC with these agencies and maximize the benefits of Spaceport Technology research.

New vehicles and systems in development could utilize the ATDC for a large portion of ground-based qualification activities. Hazardous operations, such as processing with radioactive thermal generators, could be simulated without requiring the use or handling of hazardous commodities.

Related Industry Vendors

ATDC Infrastructure will also be made available to industry for qualifying cutting-edge commercial technology for use in a spaceport environment. In this instance, the ATDC could be viewed as a spaceport version of Underwriters Laboratories Inc. wherein a controlled qualification test could be performed by a neutral party – the NASA SE&T Directorate. New systems in development could utilize the ATDC for research and qualification activities. Small companies could use the ATDC in order to reap the benefit of its large ground-based infrastructure without having to expend significant capital investment for that infrastructure.

Commercial Launch Industries

Commercial launch vendors can also utilize ATDC Infrastructure to qualify new hardware components and technologies to minimize the risk to these programs. It is envisioned that most of the commercial launch vendors will not have a large enough development budget to afford the development of separate prototype ground spaceport systems and procedures. By using the ATDC, these vendors can concentrate their efforts on the design and installation of production systems. The ATDC Infrastructure can also be made available to support initial demonstration, testing, and qualification of new vehicle development. The flexibility of the ATDC is also well suited to support the commercial launch business as a proving ground for new designs.

Academic Research

ATDC Infrastructure will be made available to academia for research of related Spaceport Technologies. In this instance, the ATDC could be viewed as a large-scale research laboratory. Joint research agreements would be developed between NASA and the academic institutions to outline the research being conducted, its duration, and which ATDC facilities would be utilized.

SUMMARY

The ATDC will be a significant facility leading the nation's development and testing of advanced Spaceport and Range Technologies. Systems that are demonstrated, integrated, and qualified at the ATDC will help lower the cost of accessing space for future generations.

If you have any questions, or desire additional information, please refer to the ATDC web site (http://atdc.ksc.nasa.gov).

ACKNOWLEDGMENTS

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REFERENCES

Interagency Working Group, "The Future Management and Use of the U.S. Space Launch Bases and Ranges," Office of Science and Technology Policy/National Security Council, February 8, 2000.

Gregory R. Clements
Advanced Technology Development Center (ATDC) Project Manager
National Aeronautics and Space Administration
Kennedy Space Center, Florida 32899
321-867-8992 (Phone)
321-867-4234 (Fax)
gregory.clements-1@ksc.nasa.gov

Project Management: As ATDC Project Manager, Mr. Clements is responsible for the planning, formulation, implementation, validation, and turnover of all ATDC facilities, systems, equipment, and technical documentation. Mr. Clements provides direction to a close-knit project team consisting of approximately 30 civil service and contractor personnel.

Previous Career: Mr. Clements has worked for NASA at KSC for over 16 years, serving for the majority of those years as a member of the NASA Design Engineering organization. Mr. Clements has been involved in several major checkout-system development projects, including the Test Control and Monitor System (TCMS) used for Space Station ground element processing and the Checkout and Launch Control System (CLCS) to replace ground processing equipment for Space Shuttle checkout and launch. Specific duties have included the designs of analog and digital printed circuit boards, data acquisition subsystem acceptance testing, project team technical management, production/manufacturing management, and systems engineering. Mr. Clements has been awarded two Certificates of Commendation and three Certificates of Appreciation and has been part of four teams that have received Group Achievement Awards.

Education: Mr. Clements studied electrical engineering at the Georgia Institute of Technology, where he received both his bachelor's (1984) and masters of science (1986) degrees in that major. While beginning his career with NASA, he attended several night classes at the Florida Institute of Technology, where he received his masters of science degree (1990) in engineering management. Mr. Clements has also attended classes in NASA's Academy of Program and Project Leadership (APPL) as well as specialized training unique to NASA-KSC.

Background: Mr. Clements was born on Bayshore, Long Island, New York and grew up in Spring Hill, Florida. Mr. Clements is currently 37 years old. He has been married for over eight years, and has three very active sons under the age of five.