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DUNS: 008373446
Cage Code: 1GUS9

NASA
NNM16ZPS002L
Technologies for Large Area Sub Arc-second X-Ray Telescopes

ADC is a small business based upon North American Industry Classification System (NAICS) code 541712 – Research and Development in the Physical, Engineering, and Life Sciences.

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BUREAU VERITAS Certification

ADVANCED DESIGN CONSULTING USA, INC.

126 Ridge Rd
Lansing, NY, 14882 USA

Bureau Veritas Certification Holding SAS – UK Branch certifies that the Management System of the above organization has been audited and found to be in accordance with the requirements of the management system standards detailed below

Standards

ISO 9001:2008

Scope of certification

Design, manufacture, and delivery of devices, integrated systems, components and instruments for commercial, academic and government agencies

Certification cycle start date: **31 December 2014**

Subject to the continued satisfactory operation of the organization's Management System, this certificate expires on: **30 December 2017**

Original certification date: **31 December 2014**

Certificate No. US007466-1

Signed on behalf of BVCH SAS – UK Branch

Certification body address: 66 Prescot Street, London, E1 8HG, United Kingdom

*Issuing office: Bureau Veritas Certification North America, Inc.
390 Benmar Drive, Houston, Texas, USA
www.us.bureauveritas.com/bvc*

UKAS MANAGEMENT SYSTEMS
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Further clarifications regarding the scope of this certificate and the applicability of the management system requirements may be obtained by consulting the organization.
To check this certificate validity please call **+(800) 937-9311**.

1.0 About ADC

ADC USA, located near Cornell University in Ithaca, New York, is a leading developer and supplier of complex engineering components and instruments for large government laboratories and corporations around the world. Founded as a privately held company in 1995, ADC has grown into one of world's leading technology companies with more than 500 customers located in over 26 countries. ADC provides machining systems and products to our diverse customers from structural metal fabrication to turn key design products with complex control systems. ADC is fully equipped with a CNC precision machine shop; and over the past several years our unique ability to fabricate/provide parts for precision vacuum machining equipment has grown immensely. Our process begins with providing quotes, which we prepare, based on specific drawing requirements given to us by the customer.

Our customers say ADC is unique because we:

- Proactively solve manufacturing challenges
- Initiate cost savings for our customers
- Innovate – in the way we build and the equipment we use
- Integrate complex systems, efficiently
- Understand schedule
- Listen to our customers

Customers are the most valuable people for an organization. They are the resource upon which the success of our business depends. The relationships we build with our customers are based upon loyalty and satisfaction. Our purpose is to fulfill the needs of the customer and they in turn make achieving our business aims possible.

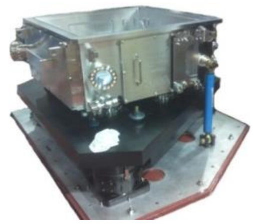
2.0 ADC ISO9001:2008

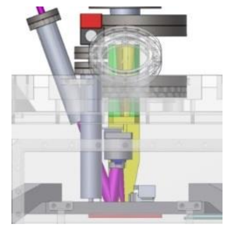
We are excited to announce that ADC has recently obtained their ISO9001:2008 certification! About two years ago, ADC began investing in developing in processes and procedures that would ultimately allow ADC to prosper. ADC's working with AM&T and Bureau Veritas was outstanding and we began scheduling regular bi-weekly meetings to ensure that our structure was developing properly. This audit was completed on November 7th, 2014 and ADC had "Zero Non Conformances". Therefore, we were recommended, by our auditor, Mr. Jim Tregaskis, for ISO 9001 official Certification. Please note Jim Tregaskis is from Bureau Veritas Certification North America, Inc.; an independent and very reputable ISO-9001 certification company.

ITAR Certified

Registration Code: M36444

The International Traffic in Arms Regulations (ITAR) is a set of regulations that govern the export and re-export of certain controlled commodities, services, and, most importantly, technologies. ITAR registration recognizes ADC as a manufacturer fully capable to support all military and homeland security projects in the U.S. In accordance with ITAR requirements, ADC is entirely owned and operated by U.S. citizens.





4.0 ADC's Capabilities

Engineering Design and Analysis

The Engineering Design and Analysis group is a multi-disciplinary team of engineers with unique training and creativity, and dedication to meeting the needs of our customers. ADC uses the latest computational and graphics software and hardware to approach the most challenging problems in the Aerospace, Automotive, Nuclear, Turbomachinery, Automated Machinery, Electro-Optical Products, synchrotron, high energy physics, and neutron diffraction communities. Parametric solid models are created for all mechanical designs, using Autodesk Inventor 2014 Professional. Drawing on our extensive experience, we present practical, economical and safe designs. We stand apart by providing a multidisciplinary approach - in materials, modelling and manufacturing to the design process. We review design and fabrication requirements, scoping and detailed stress analysis, determining specification and regulatory constraints, and working to practical cost limitations.

These models are the basis for procurement, manufacturing and assembly, ensuring accurate and timely execution of the designs. Autodesk Inventor 2014 comes with a finite element package capable of many different types of simulations including stress analysis, modal analysis and thermal analysis. These simulations as well as ANSYS are used for providing numerical results that cannot be efficiently calculated by hand. With a dedication to customer satisfaction backed by over 18 years of experience in developing innovative designs, we are confident we can tackle and solve the most challenging problems; examples below.

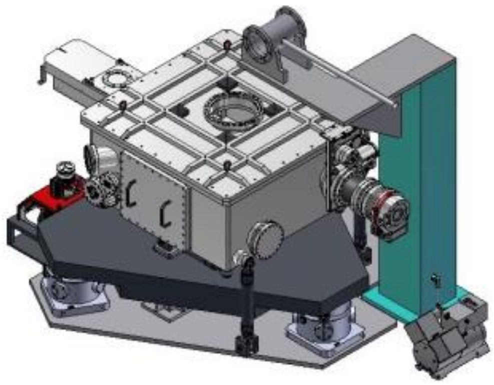
Arecibo Observatory Upgrade

The Arecibo Observatory telescope in Arecibo, Puerto Rico, the largest and most sensitive single dish radio telescope in the world, got a good deal more sensitive. Thanks to ADC! In April 2004 the telescope got a new "eye on the sky" that helped turn the huge dish, operated by Cornell for the National Science Foundation, into the equivalent of a seven-pixel radio camera.

For more information please visit: http://www.adc9001.com/Arecibo-Observatory-Upgrade

Finite Element Analysis

ADC Engineers perform structural design and analysis for the manufacturing, aerospace, Electro-Optical Products, synchrotron, high energy physics, and neutron diffraction communities. We perform finite element analysis (FEA) to accurately model products and processes to determine structural integrity, performance and reliability, as well as predict structural failures. ADC uses FEA for decreasing design cycles, keeping production costs low through design optimization, and uncovering potential sources of field failures.

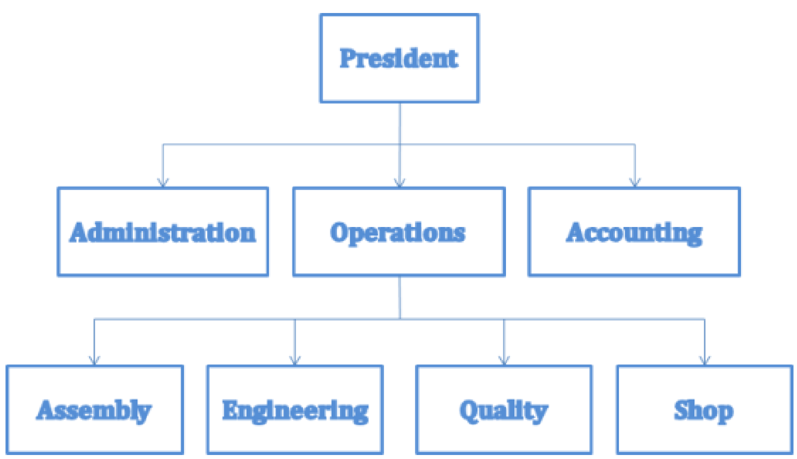


ADC uses Finite Element Analysis (FEA) to predict the deflections of complex and critical structures and to solve the most challenging product engineering problems. For example, when ADC's engineers design insertion devices, the magnet support structure behavior can be simulated in ANSYS by applying the anticipated magnetic forces, which are determined from a RADIA calculation. Solid models generated using Autodesk Inventor can be imported into ANSYS, greatly simplifying the interactive design process. Many aspects of the design, such as material selection, girder geometry, bearing size and preload, and magnet clamping are optimized using FEA. Below is a typical example of what you would expect to see from ADC, including a solid model, finished product and installed product.

Optics Design

ADC uses SHADOW a widely used program for the simulation of optical systems, more geared to the synchrotron radiation research. It is based on a geometrical ray-tracing approach, but also traces field amplitude with phase difference. This design tool is used by ADC in combination with ADC's High Accuracy Optical Mirror Metrology Profilometer.

Organization



ADC employs a team-based structure that provides a distinctive advantage in the overall success of the organization. Common processes and integrated team based concepts allow for effective and efficient program management. We measure the performance of our teams through feedback channels that allow for continual improvement. This element is essential to the team's ability to meet and exceed their objectives. Through the team process, with a focus on our vision of being our customer's premier supplier, we provide the highest level of customer satisfaction possible.

Each week ADC's Operations Manager reviews the status of all projects currently running in ADC with each project's team leader. This is a devoted time for each team to communicate important team-based and corporate information. Every team is empowered to hold other meetings as needed to ensure all customer specific requirements are met.

5.0 ADC Vibrational Analysis

Advanced Design Consulting uses vibrational modelling and measurement techniques to predict and define the vibrational characteristics of high stability systems. FEA Vibrational Analysis is used during the design process to predict the frequency and shape of vibrational modes and to improve the vibrational characteristics of the design. Once a system has been built, vibrational measurements are taken to verify the results of the FEA model and to generate a frequency response curve.

<u>Vibrational Modeling using Autodesk Inventor Modal Analysis</u>

Using finite element analysis (FEA) methods through Autodesk Inventor, the undamped vibration modes of a structure can be analyzed to determine their shape and frequency. The results of such an examination have two important uses: first they provide the natural frequency (ω_0) of the structure, and second, they provide an indication of the direction of least stiffness in a structure. Prediction of the structure's natural frequency is useful for the design of stable platforms for scientific instruments, while prediction of least stiff directions in a structure is useful for the design of flexures and the design of particularly rigid objects. The first mode returned by the analysis is the undamped natural frequency, while all of the higher modes are harmonics. Resonance (amplification) can occur if the system is driven at any of these frequencies by vibrations through the floor, through water cooling lines, through turning motors, or by any other ambient vibration. An example modal analysis performed for an optical table is shown below

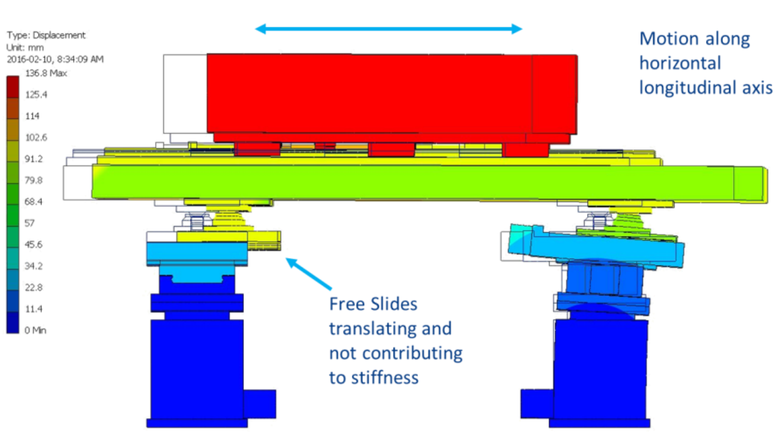


Figure 1: Initial FEA results for the first mode of an optical table oscillating at 15.9 Hz. The results of this FEA analysis led to the addition of locking mechanisms on the free slides which increased the stiffness in the horizontal direction and raised the frequency of the first mode of the system.

Measurement of Vibrational Characteristics

Once a system has been assembled, ADC can perform vibrational measurements to generate a frequency response graph for the system. This response is measured using a high resolution accelerometer connected to an oscilloscope. The system is excited using a dead blow hammer and the vibration and damping of the system is recorded by the oscilloscope output. A Fourier analysis is conducted to transform the accelerometer output into a frequency response for the system. Several tests are performed and measurements are taken in multiple locations to ensure an accurate measurement of the system's properties. These results are recorded in a vibrational analysis test record and sent to the customer. An example test record is shown on the next page for the mirror system shown below.

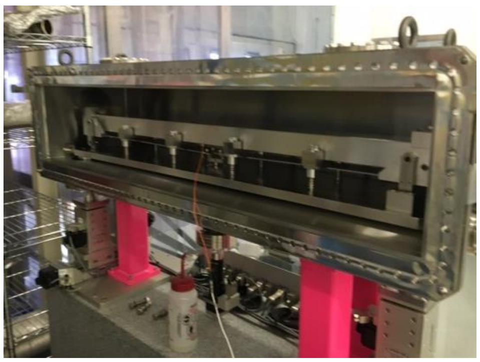


Figure 2: Mirror vibration test setup.

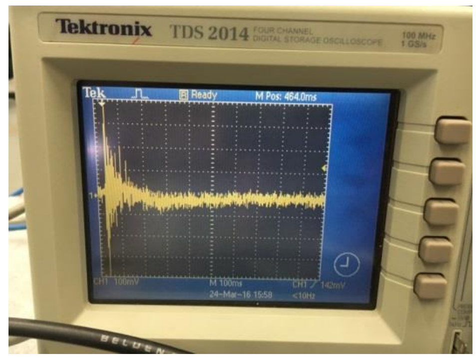


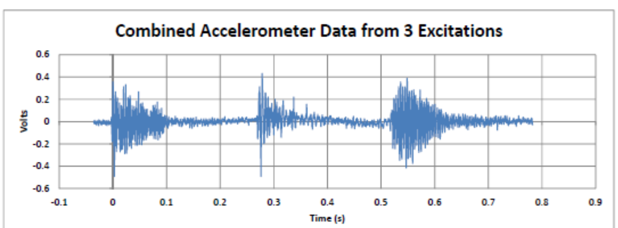
Figure 3: Oscilloscope output from the mirror vibration test.

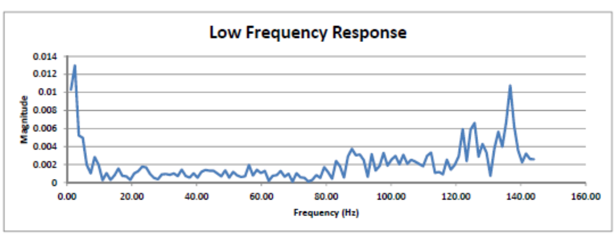
Vibration Analysis Test Record

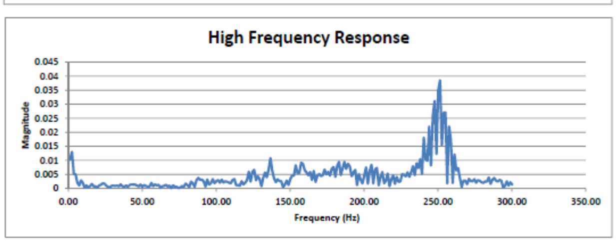
FORM-00009 Rev1.6, 2015-01-29

Measurements taken using a Tektronix 4 Channel Oscilloscope connected to an accelerometer.

Measurement Settings:				
Oscilloscope Sec/Div.:	100	ms	Device Name	ANL Mirror
Number of Data Points:	2500		System Serial Number:	N/A
Sample Interval:	4.00E-04	s	Job number:	15-002
Sample Frequency:	2500	Hz	Test Date	2016-03-24
Number of Data Points used in Fourier Analysis:	2048		Entered data is in Red	
			Calculated values are in Dark Blue	
Fourier Frequency Interval:	1.22	Hz	Unused Cells are Grey	







ADC's HIGH ACCURACY OPTICAL MIRROR METROLOGY PROFILOMETER

ADC has developed an optical profilometer for non-contact measurement of the flatness and bending of X-Ray focusing mirrors with a large measurement range and high accuracy for synchrotron applications. The optical non-contact measurement simultaneously reads from 2 independent CCD line detectors, one for each measurement axis. The completely digital signal reception and processing guarantees exact linear behavior across the entire measuring range. This type of measurement requires sub-nanometer resolution and repeatability for current and future metrology of x-ray optics for the next generation of light sources.

The massive gantry system includes two axes motion, which are orthogonal, high precision metrology axes. One of the two motions provides 2 m translation and the other motion is for lateral scanning of the mirror surface. The system's frame and optical stand are made of granite with nearly 14,000 Kg of high precision, low expansion coefficient stone resting on a three-point kinematic mount. The top optical carriage is an extremely stiff carriage with 0.1 µm resolution encoder from Renishaw and Newport Corporation bread board on top.

The gantry system is driven by an industry-leading (Gallil DMS40x0 with a Labview interface) high performance controller. The controller is compatible with the Experimental Physics and Industrial Control System (EPICS).

	Specification	
1	Accuracy, arcsec	± 0.1 over any 20" range ± 0.25 over total range
2	Number of measuring axes	2
3	Mirror Size, mm	Length 2000 x Width 300
4	Angular Range, arcsec	2000
5	Acquisition Range, degree	1
6	Resolution, arcsec	+/- 0.005 up to 10; selectable
7	Reproducibility, arcsec	+/-0.05
8	Focal length, mm	0.05

The optical metrology of mirror systems is necessary to both qualify bending mirrors for operation in synchrotron beamlines and to quantify the errors in bending so these mirrors can produce optimum performance. Typically, mirrors are measured in the flat, unbent, state by the manufacturer and this data is provided to the user. However, the user also needs to know the shape of the mirror in the bent state to calibrate the bending mechanism to the selection of X-ray wavelength of interest. This calibration is usually done on a high-accuracy profilometer. The operation must be non-contact to avoid damage to the mirror under test.

Current and older profilometer systems are limited in the accuracy required for the qualification of newer mirror systems used in synchrotrons with highly coherent beams. A recent collaboration between APS and BESSY to replace the aging APS Long Trace Profilometer (APD LPT-II) has resulted in the development of the next generation optical slope measurement systems (OSMS) leading to the installation of the Nanometer Optical Component Measuring Machine (NOM) at APS in 2012 [1].

ADC has developed an unprecedented optical profilometer for non-contact measurement of the flatness and bending of X-Ray focusing mirrors with a large measurement range and high accuracy for synchrotron applications.

The optical non-contact measurement is based on the Vermont Photonics Elcomat 3000 autocollimator. Shown in figure 1 below, this autocollimator simultaneously reads from 2 independent CCD line detectors, one for each measurement axis. The completely digital signal reception and processing guarantees exact linear behavior across the entire measuring range. This type of measurement requires sub-nanometer resolution and repeatability for current and future metrology of x-ray optics for the next generation of light sources.

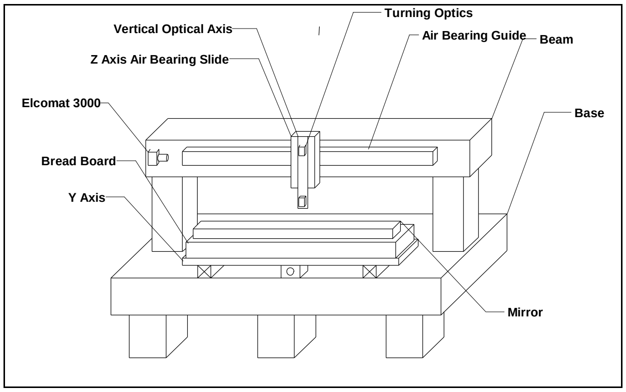
Elcomat 3000 Autocolimator

A massive granite split axis system includes two axes of motion, which are orthogonal, high precision metrology axes. One of the two motions provides 2 m translation over the top of the optic while the other motion is for lateral scanning of the mirror surface. The optic is mounted to the lower axis on a table that allows bending of the optic. The system frame and optical support are made of granite with nearly 14,000 Kg of high precision, low expansion coefficient stone resting on a three-point kinematic mount. . The split axis design allows the most precise alignment of orthogonal axes that can be obtained because straightness of one axis is not dependent on the other.

The system controls consist of an industry-leading (Gallil DMS40x0 with a Labview interface) high performance motion controller. The controller is compatible with the Experimental Physics and Industrial Control System (EPICS).

	Table 1: System Specification	
1	Accuracy, arcsec	± 0.1 over any 20" range ± 0.25 over total range
2	Number of measuring axes	2
3	Mirror Size, mm	Length 2000 x Width 300
4	Angular Range, arcsec	2000
5	Acquisition Range, degree	1
6	Resolution, arcsec	+/- 0.005 up to 10; selectable
7	Reproducibility, arcsec	+/-0.05
8	Focal length, mm	0.05

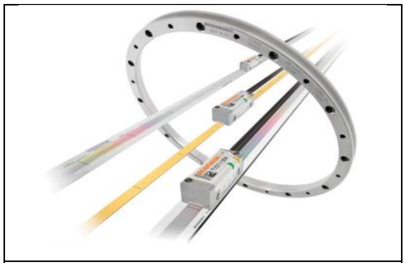
ADC's High Accuracy Optical Mirror Metrology Profilometer uses a massive granite base that provides for thermal and vibration stability as shown in Figure 2 below. The base rests on 3 points with fine adjustment.



On top of the granite base, there is an ultra-precision motorized X axis with 300 mm travel. This is a low profile axis with providing a stiff, repeatable support. An optical bread board mounted to this axis provides a means to easily mount any type of mirror and bending mechanism. This direction corresponds to the typical X or lateral direction of a synchrotron.

A granite beam resting on granite supports resides over the X stage. A carriage holding the system optics is mounted to the beam moves in the mirrors longitudinal or Z direction. The Z axis consists of an air bearing guide rail with a small carriage driven on the center of gravity with a linear motor. The travel is 2 meters.

Both axes are driven on center using a Renishaw Tonic [3] linear encoder (Ti20KD) with a resolution of 1 nm per count – see Figure 3 below. The encoder is made of Invar for thermal stability. The motion of the axes is mapped with a laser and a volumetric calibration table is applied to correct for any positioning errors. A Renishaw laser was used to map the errors in the system applying the ASME B5.54-2005 standard as was done at APS. This provided the corrections for each axis based on the location of the other axes.



Renishaw Tonic Linear Encoder

Sensors

ADC also incorporated thermal and vibration sensors to monitor the environment at the High Accuracy Optical Mirror Metrology Profilometer. There are 3 RTD thermal and 3 vibration (for X,Y,Z directions) are mounted at strategic locations and monitored by the local PC.

Thermally Stable Room

The High Accuracy Optical Mirror Metrology Profilometer resides in a thermally stable, clean, environment with humidity and temperature control.

References

[1] Lahsen Assoufid, et. al. Development of a high performance gantry system for a new generation of optical slope measuring profilers, Nuclear Instruments and Methods in Physics Research, A 710 (2013) 31-36

[2] Elcomat 3000 Sales Brochure, 2009, Vermont Photonics Corporation

[3] Renishaw, Sales Brochure, Tonic Encoder System, L-9517-9337-03-C, 2009, Renishaw Corporation

The Arecibo Observatory, home of the world's largest radio-radar telescope, went through a major upgrade that maked it one of the most sensitive and powerful tools ever designed for astronomical studies.
http://www.adc9001.com/Arecibo-Observatory-Upgrade

ADC designed the large turntable, capable of positioning the receiver heads to within .5 mm (taking into consideration the weight budget and achieving the required velocity). ADC also designed the positioning systems for the tertiary sub-reflector and the eight new receiver heads. This project was part of a $25 million upgrade to the Arecibo facility. A Gregorian reflector system now hangs from the main detector area 137 meters (450 feet) above the main reflector dish. The Gregorian dome contains two reflector dishes, a radar transmitter, and microwave receivers. The secondary and tertiary reflectors channel the signal from the main reflector into the receivers.

ADC also provided design and analysis for a metallic shield to be placed around the edge of the tertiary reflector at NAIC's Arecibo Gregorian system in order to reduce the noise temperature contribution from the Gregorian dome enclosure.

Item	Description	Statement of Compliance
1	angular resolution of 0.5 arcsecond or better	ADC complies to the requirement provided.
2	effective area up to 3 square meters in the roughly 0.1 to 10 keV range	ADC complies to the requirement provided.
3	light weight (1 kg/m2 areal density) mirrors	ADC will fo the FEA calculations and weight reduction analysis. Please see page 4 for further details
4	low cost (1M$/m2 mirror surface area)	ADC will get the quotes from different mirror manufacturers. We work in close collaboration with SESO - the mirror will be fabricated by them. They typically provide us with the best pricing.
5	high-resolution	ADC complies to the requirement provided.
6	mirror coating processes and methods for stress mitigation	ADC complies to the requirement provided. The mirror will be coated with special materials such as Rhodium (Rh), Platinum (Pt), with a base coating of Chromium (Cr). The surface roughness is measured in Angstroms
7	static and active post-fabrication figure correction techniques	ADC complies to the requirement provided. We have an extensive facility to complete the work.
8	mounting and assembly schemes	ADC complies to the requirement provided. ADC has been in business for over 20 years with experience. For further documentation regarding Assembly, Testing, and other capabilities of ADC please send a request to ashley.jenner@adc9001.com
9	alignment; metrology; and mass production approaches to any of these topics.	ADC complies to the requirement provided. Recently ADC has completed a 2,000 square foot expansion to our manufacturing department allowing more space for mass produced projects.
10	a description of the technology, what technological challenge it addresses and how it confronts that challenge in the context of the desired sub-arc second, large-area X-ray optic	ADC Complies. Please see pages 6-10
11	an estimate of the current Technology Readiness Level and a justification for that estimate	ADC Complies. TRL 5
12	a plan and schedule for advancing the technology to TRL 6.	ADC Complies. Please see pages 6-10