Lester M. Cohen

Chief Engineer, Structural Analysis & Design Group @ SAO

Lead Mechanical Engineer, NASA JWST Optical Telescope Element

Education:

BSCE 1973, Northeastern University

MSCE1977, Northeastern University

Post Grad: Numerical Modeling of Physical Systems, MIT, 1977

Employment:

Stone & Webster Engineering; 1973-1974

Northeastern University: 1974-1975, Lecturer in Civil Engineering, Northeastern Univ.

Teledyne Engineering Services: 1974-1978

Smithsonian Astrophysical Observatory: 1978- present

Professional Skill:

Accurate, focused & cost effective analysis & design of opto-mechanical equipment for ground & space based telescopes & scientific equipment. Innovative mirror support concepts & designs for ground based metrology & lightweight flight optical systems. Highly focused skills as a reviewer of designs & hardware proposed & produced by others. Highly effective member of numerous review committees for current & future NASA programs. Mentor to a small and highly efficient group of engineers at SAO.

Professional Awards:

Numerous NASA Public Service Medals & Group Achievement Awards

NASA Distinguished Public Service Award 2009

Publications:

1982 "Conceptual support design of the High Resolution Mirror Assembly for the Advanced X-ray Astrophysics Facility (AXAF), L.M. Cohen, SPIE, **330,** 49

1982 "Concepts For An Optimized Kirpatrick-Baez Mirror Module For A High Throughput LAMAR Facility" L.M. Cohen, P. Gorenstein, Technology For Space Astrophysics Conference: the Next 30 Years, AIAA/SPIE/OSA

1983 “Structural mechanics of optical systems”, SPIE, **450,** Letser M. Cohen, Chairman/Editor

1983 "The Effects of Epoxy Shrinkage On The Advanced X-ray Astrophysics Facility Technology Mirror Assembly", L.M. Cohen, SPIE **450**, 95

1986 "Design, analysis, fabrication and test of the LAMAR protoflight mirror assembly", L.M. Cohen. SPIE, **691**, 126

1990 "Structural considerations for fabrication and mounting of the AXAF HRMA optics", L. Cohen et al SPIE, **1303**, 162

1995 "Effects of temporal dimensional instability on the Advanced X-ray Astrophysics Facility (AXAF-I) high resolution mirror assembly (HRMA)", L.M. Cohen, SPIE, **2515**, 375

2003 “Computer Models of Micrometeoroid Impact on Fused Glass Mirrors”, David Davison, et al, International Journal of Impact Engineering, **29**, 203

2012 “Space telescope design considerations”, Lee Feinberg, et al, Opt. Eng., **51**

2015 “ATLAST: ULE mirror segment performance analytical predictions based on thermally induced distortion”, Michael Eisenhower, et al, SPIE, **9602,**9

Description of Past 5 years work

Since 2001 I have held the position of Lead Mechanical Engineer (LME) for the James Webb Space Telescope Optical Telescope Element (OTE). This position was offered to me by NASA/GSFC based on similar work I performed on the highly successful Chandra Observatory and the familiarity of this work by the NASA/GSFC OTE manager at the time. In the past 5 years, the work I accomplished individually, with my small highly efficient JWST group here at SAO, or within the context of the larger JWST community consists of but is not limited to the following:

1. Development of a precision off-loading system (coined the Lester Levitator by EKC/ITT) for nano-meter quality optics. This system was originally developed to support thin (0.25-0.5mm thick, 0.25m diameter, 0.4m long) nickel & silicon carbide shells for x-ray mirrors systems. These designs were modified to work with the early JWST mirror designs (termed the Advanced Mirror System Demonstrator (AMSD)). These designs were successfully used for think meniscus mirrors (Hughes Danbury Optical) and semi-rigid designs (EKC/ITT).
2. Development of micro-meteoroid test equipment for glass and beryllium substrates , post test data analysis, and post test model formulation for mimicking the effects of micro-meteoroids on mirror figure. These results were then used by Ball for their predictions for the Primary Mirror Segments & the Secondary Mirror Assembly end of life figure changes.
3. Identification of the beryllium manufacturing (machining, grinding & polishing) processes that lead to stress being formed in the substrate & how this could be minimized such that short term & long term mirror figure goals could be attained. Development of a creep model for long term mirror figure predictions. Development of a elastic plastic model for beryllium based on test data that could be used to accurately predict the effects of launch on nano-meter quality optics. These models were subsequently used by Ball to show compliance with their mirror figure requirements.
4. Light-weighed optimized design for ground-based metrology, launch stresses, on-orbit thermal environment and manufacturability of the JWST beryllium substrate. Improvement to the predicted the figure changes when the radius of curvature system was operated as well as when optic was moved within its full range of correctability w/ its 6 DOF actuators.
5. Identified the cause of cracked beryllium blanks during the HIPing (hot iso-statically pressed) process at Brush-Wellman. Recommendations (cooling rates, acid etch methodology, etc eliminated the cause of the failure.
6. Thermo-elastic modeling & model correlation of composite structures at room temperature & cryogenic temperatures. I identified the “sub-standard” modeling that was being utilized by ATK at the time to model the effects of cryogenic distortions. I introduced the method of using a “gold standard” for

all modeling. This was subsequently used for all JWST modeling related to the large composite structure that hold the mirror segments.

7. Accurate physical modeling of composite parts & structures & their failure modes. This contribution was specifically noted by the JWST Program Manager in his Space News interview in 2008.
8. Development of a simplified epoxy creep model to account for temperatures above the glass transition temperature T_g . This model was test verified via double-lap shear test data. This model was used to predict the on-orbit mis-alignments caused by ascent temperatures reaching abnormal levels. This simplified modeled agreed with a much more complicated and complete model developed at ATK to within 10%. This simplified model was much easier to use & was used on the entire composite structure that supports the JWST mirrors.
9. Later this decade, the JWST will be transported to the NASA/JSC test facility & subjected to a space-like environment. During these tests, the optical wave front of the telescope will be monitored as the temperature of the facility is slightly changed. This is in order to mimic what happens in space when the telescope is slewed & its temperature changes a small amount. This test, called a thermal distortion (TD) test, requires hundreds of thermal sensors to be place on the telescope at locations where temperature measurement errors would cause large errors in our wave front predictions. My team & I have produced highly regarded technical results where different optimization schemes have been utilized. The results of this study is now the basis for future work by NASA/GSFC.
10. During the test described in 9) above, small changes in the modulus of elasticity of the composite parts may significantly affect the predictability of the wave front error. I have devised a test to gain additional insight into this area. The theory is to measure the natural vibration of a composite part as its temperature is changed fro 293K to 25K and to understand all of the parameters that go into the frequency shift. The cantilever beam was designed to have low sensitivity to all parameters EXCEPT the longitudinal modulus of the beam which also drives the gravity induced wave front error. Preliminary results are very encouraging. They indicate that the composite modulus is actually ~5X less sensitive that previously measured (with less precise instrumentation). This can reduce the program risk considerably
11. The large composite structure that supports the mirrors will be subjected to a 25K environment during cryogenic cycling at the NASA/MSFC XRCF. Post cryo cycling, some epoxy bonds will not be able to be measured using NDE techniques. While the probability of failure due to this cryogenic cycling is small, the risk of a failed bond is immense when we subject the structure to flight-like static tests after the cryogenic cycling. In order to understand the risk of a bond failure, my team and I analyzed each & every one of the ~300 bonds that cannot be re-measured w/ NDE via a redundancy analysis. In this analysis each one of the 300 bonds is removed, one at a time, and the increase in stress in all other local bonds in the vicinity of the removed bond are monitored. We found that there are only a handful of bonds where the

increase in stress is considered to be problematic; that is it would exceed some allowable stress threshold. These few areas will be analyzed in greater detail. So we have found that the risk to the program is small (its magnitude was previously unknown) & manageable if we monitor only a few concise areas.

12. I have been a key member of numerous review committees for JWST (and a few outside of JWST based on his JWST & NASA work. These include being a member of the JPL Terrestrial Planet Finder Technology Demonstration Mirror (TDM) Program). One of my assignments was to review the work of Lockheed for the JWST NIRCam. My review report is attached to show the depth to which I take this role seriously. In the end, NIRCam did change the design of the support for all of their optics & it has performed according to plan.
13. Much of the SAO work on JWST has been associated with Company Proprietary information and therefore this work cannot be shared. However, two examples will be described. A) During final polishing of the beryllium optics it was noticed that the figure of the mirror changed more than expected near the edge of the optics. This problem was brought to SAO attention. After we were provided the tool design & its path we found that the tool was much too stiff. We redesigned the tool & the redesigned tool was put into use. The problems were significantly reduced. B) During the cryogenic testing of the JWST as described in 9), the vibration of the chamber support system will be dampened-out with large vibration isolators. I was the only individual outside of the company to review the dynamics model of the system. As soon as that model was reviewed an obvious problem was found. The company fixed the problem & we currently predict that chamber vibration will be a non-issue.
14. Supports internal SAO reviews as directed by the Director of CE.
15. In 2009, I was awarded the NASA Distinguished Public Service Medal for his contributions to two of NASA's Great Observatories; Chandra & JWST.

    "This is NASA's highest form of recognition that is awarded to any non-Government individual or to an individual who was not a Government employee during the period in which the service was performed, whose distinguished service, ability, or vision has personally contributed to NASA's advancement of United States' interests. The individual's achievement or contribution must demonstrate a level of excellence that has made a profound or indelible impact to NASA mission success, therefore, the contribution is so extraordinary that other forms of recognition by NASA would be inadequate."

16. Strives to always instill into his analysis & design group a goal of providing high quality design & analysis services but more importantly providing good overall engineering. Each engineer must act, always, for the good of the project. Each engineer should make himself as fully aware of all intertwined

requirements as possible so that they can do a more thorough, complete & valued task.