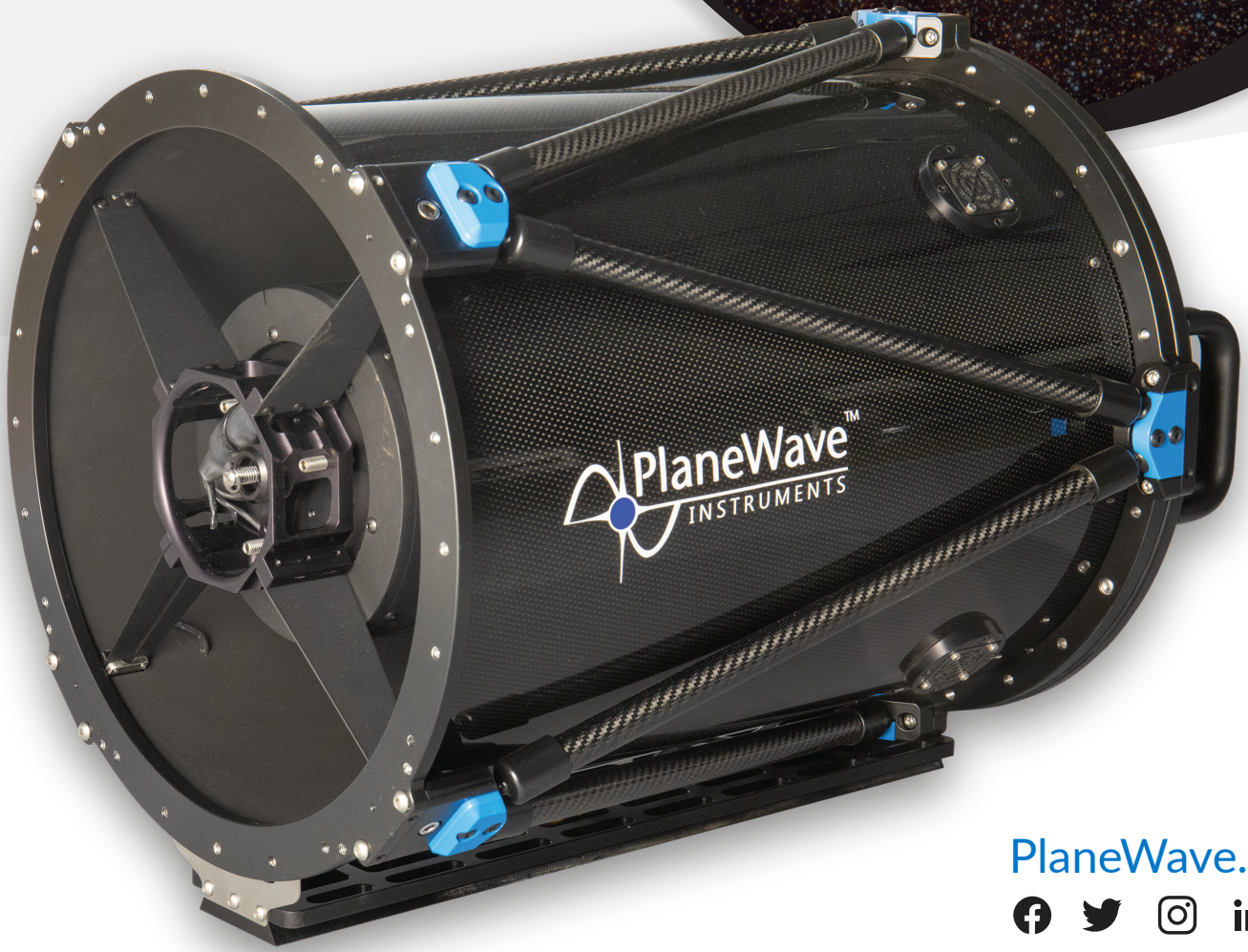
PlaneWave™ INSTRUMENTS

DeltaRho 350

350MM ROWE-ASTROGRAPH



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Advanced imaging applications demand systems that can keep up, and the DeltaRho 350 is designed and made for uncompromising performance as a fast, wide-field optical system. Inspired by the challenges of Space Domain Awareness (SDA), astronomical research surveys, and demanding astrophotographers, PlaneWave's engineers developed an elegant, new optical design that meets PlaneWave standards for imaging performance and ease of use. The DeltaRho 350 offers Cassegrain focus at a focal-ratio of f/3. Born from our heritage and insight as one of the world's leading designers and manufacturers of high-performance telescopes, we believe you will find the innovation, resolution, and contrast of the DeltaRho just as amazing as its speed and field-of-view.

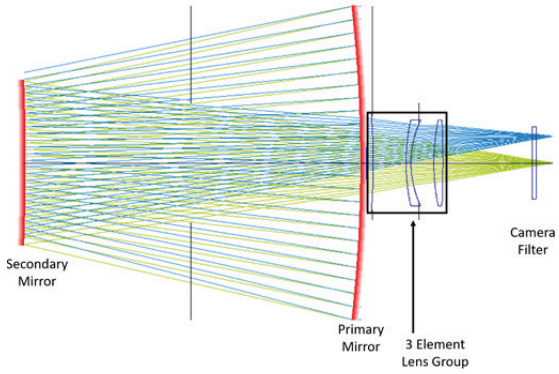
DeltaRho 350
FEATURES

Optical Design

The DeltaRho optical design evolved from the revolutionary CDK (Corrected Dahl-Kirkham) telescope design, created by David Rowe (our CTO) and introduced by PlaneWave in 2006. Both designs include field-corrector lens-groups near the focal-plane, use ellipsoidal (aspheric) primary mirrors, and spherical secondary mirrors. This approach to corrected Cassegrain optics is elegant in its simplicity, and effective in creating flat, well corrected images from competitively priced telescopes.

Due to the much wider field-of-view, the DR350 features a 3-element corrector-lens group, compared to the 2-element group seen in the f/6.5 – f/8 CDK optical-tube-assemblies.

Using glasses of three unique refractive indexes allowed PlaneWave's optical designer to achieve correction across an image circle that is larger than most of today's detectors, while limiting chromatic dispersion to less than 1/3rd the depth of the critical focus zone.



Zoomed in view of the Pinwheel Galaxy core using 5 x 2-minute unguided exposures with a ZWO6200M CMOS camera (3.8um pixels).

Stray-light mitigation is important for every telescope and is even more critical for wide-field systems. PlaneWave's engineers designed the DeltaRho optics, mechanics, and baffles with this first-in-mind. Careful ghost analysis has been conducted to ensure that lens reflections never reach the focal-plane, and light baffles have been carefully placed to prevent unwanted reflections from OTA mechanics, maximize image contrast. An f/3 focal-ratio telescope can quickly capture faint subjects and details, and one with effective stray-light mitigation will do so even faster.

Field of View and Resolution

You know a wide field of view is exactly what you need, but what about resolution? The DeltaRho 350 boasts a 3.2-degree field of view over its 60mm image-circle. It also produces tightly focused stars across this enormous field. On-axis, the system produces RMS spot sizes smaller than 1-arcsecond (4.95 microns). At the edge of field, the spot-size is just under 1.5-arcseconds (7.56 microns). This level of resolution is a great match for many applications and sites around the globe, ensuring DeltaRho 350 images are both wide and sharply detailed.

USA-Made Optics

PlaneWave is proud to make and qualify our mirrors in-house, at our optical production facilities in both Southern California and Michigan. This ensures that every mirror can be tested at every step of the fabrication process and allows us to inspect our optics as both individual elements and as finished telescopes. We know that exceptional system performance is what our users expect, which is why PlaneWave CNC generates, grinds, polishes, figures and mounts our own mirrors. We have also created proprietary testing metrology and our own robotic optics machines to be able to deliver exceptional optics at exceptional value, all made in the USA.

PlaneWave™ INSTRUMENTS

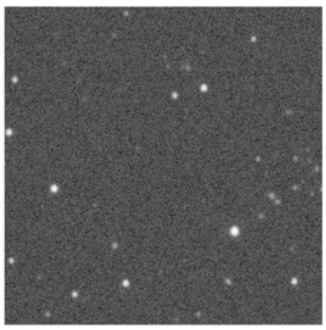
DeltaRho 350 FEATURES

Edge Performance

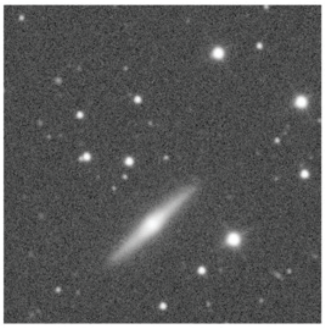
Single 2-minute unguided exposure, ZWO6200M, 3.8um pixels.

Top Left

Top Right



Bottom Left



Bottom Right

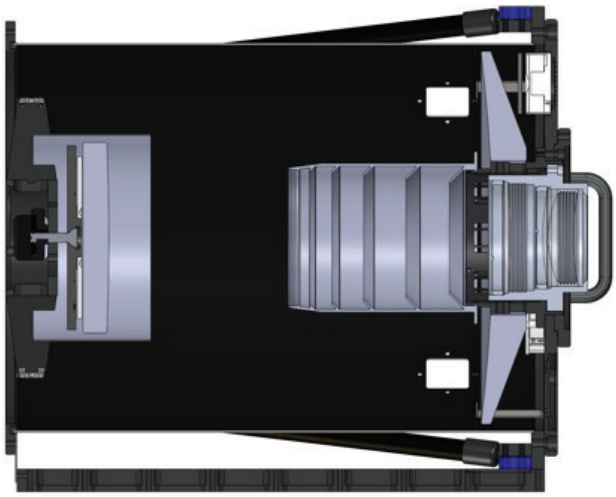
Cassegrain Focus

The DeltaRho 350 is a Cassegrain focus system for one reason: versatility. Some applications call for very simple equipment solutions, while others require much more. Even modest instrument packages or filter-wheels can become challenges for prime-focus designs, blocking light from reaching the optics while adding diffraction to the image. We want you to have the flexibility to use the filter wheels and filters needed to illuminate this 60mm field, or to integrate other large instrumentation that is best to have behind the telescope.

Advanced Light Baffle Design & Fabrication

At their most elementary level, optical baffles prevent the focal plane from seeing light which has not been focused by the optical system. In other words, they prevent the sensor or eyepiece from seeing direct illumination from the subject or scene. However, even the blackest of paints and metal finishes still reflect some amount of light, particularly at grazing angles. More advanced baffle shapes make all the difference.

In PlaneWave's computer-aided, advanced baffle design, additional light-trapping features are added, allowing the capture and mitigation of diffuse reflections from within the optical system. Years of related R&D have led to new approaches to baffle shaping, and to PlaneWave innovation in 3D-printing of our most complex baffle designs. Traditional fabrication, like machining or molding, cannot economically and precisely produce these structures. So, we began printing our baffles in 2010, achieving the best stray-light prevention you will find in commercially manufactured telescopes.



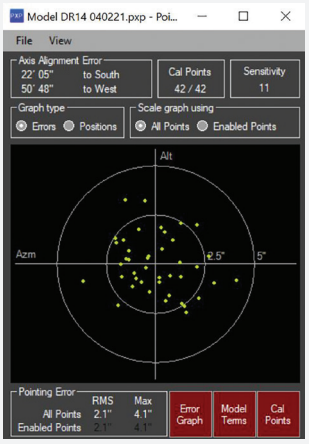
These perspectives and approaches have been beautifully delivered in the DeltaRho 350. Within the primary-mirror baffle, there are nine smaller 'bafflets'. Notice in the cross-sectional drawing that the light-facing surfaces of each feature will bounce light away from the focal-plane. With similar treatment applied to baffles within the corrector-lens assembly, the results are breathtaking. We have been amazed by the contrast of images taken during prototyping of the DeltaRho 350 and cannot wait to see the beauty you produce with yours.

DeltaRho 350 FEATURES

Mechanical Stability

Keeping optics properly aligned is the first and only job of a telescope's mechanics, and faster focal-ratio systems make this an even greater challenge. PlaneWave fully understood this while beginning to design the optical-tube mechanics of the DeltaRho 350, and they have delivered an incredibly well performing structure. In use with the L-350 Direct-Drive Mount, DeltaRho 350 telescopes have shown pointing-model accuracy in the range of 1.5 to 3.0 arcseconds RMS. Naturally, every element of the system is part of this performance, but there is one very important part that is unique to PlaneWave.

The primary mirror in the DeltaRho 350, the heaviest optical element in the system, is fixed in place. This truly is a big deal. It requires more work and attention during epoxy-mounting of the optics and assembly of the telescope, but there are two clear advantages:



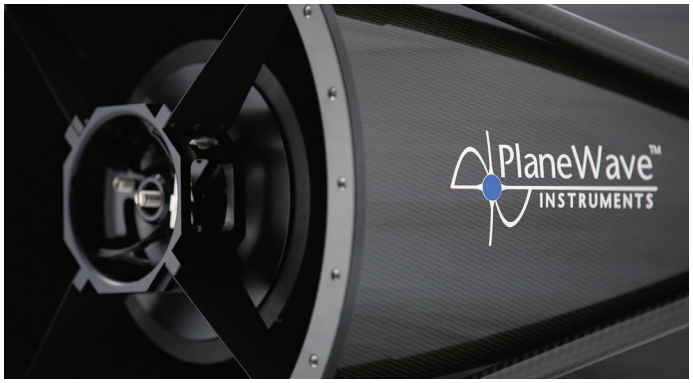
PWI4 software pointing model results with the DR350 & L-350 mount. Pointing error for the 42-point model was 2.1 arcsec RMS error.

Rigidity – When angular differences measured in arcseconds matter, a fixed primary mirror is an important foundation. Our epoxy-bonded primaries do not tip or tilt over time, relative to the backplate or front-ring. Consider competing systems, where adjustable mechanics support the primary, and you are expected to use those adjustments. Our method ensures the optical and mechanical axes of the telescope are aligned to eliminate image-plane tilt. If there is tilt within the camera itself then our optional adjustable tilt adapter will help solve that.

Single-Mirror Collimation – With PlaneWave technicians having aligned, and rigidly mounted the primary mirror to the OTA backplate, there is only one optic to adjust in collimation – the secondary mirror. This defeats the challenge in maintaining other Cassegrain-style telescopes, where there are independent adjustments for both the primary and secondary mirrors, as well as the focuser. Simplified collimation may take more thought and effort in the factory, but makes life in the field more fun, and ensures your optics produce their best images.

Thermal Control and Stability

From the materials used in fabrication, to the integration of dew heaters and temperature sensors, to the placement of 7 fans on a 350mm aperture telescope, the DeltaRho 350 incorporates a variety of features designed to control and withstand the changing environment in the field.



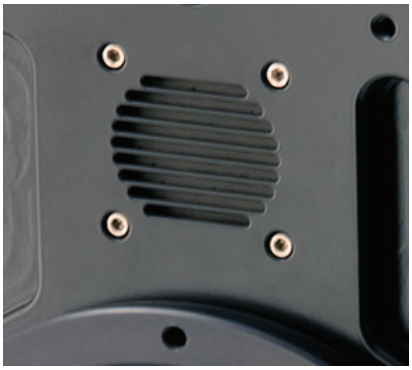
Fused Silica Mirrors – Like all other current PlaneWave telescopes, the DeltaRho 350 includes mirrors produced from fused-silica (Quartz). With a very low coefficient of thermal expansion, use of Quartz optics ensures that changing temperatures do not result in mirrors changing shape.

Carbon-Fiber Truss – Carbon-fiber is lightweight and incredibly strong, but it can also be manufactured to not change length over temperature. Combined with careful attention to fittings, geometry, and mechanical strain relief, supporting the major length of the optical axis with carbon-fiber has allowed PlaneWave engineers to create a thermally stable structure.

Dew-Heating System – The DeltaRho 350 is pre-wired and ready for connection to the 5-Series Controller. Within the OTA, polyimide heating pads are carefully placed to offer even heating of the primary and secondary mirrors, when ambient temperature and dewpoint are too close for comfort. Additionally, multiple temperature sensors allow the system to know just how much to heat each optic, and these settings are all controllable within PlaneWave software.

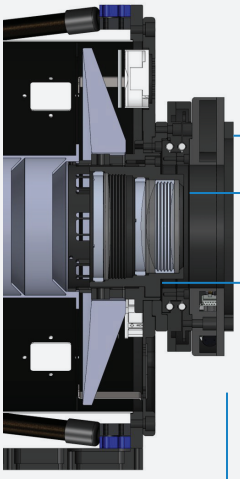
DeltaRho 350 FEATURES

Fans for Cooling and Tube-Seeing – Most telescope users are familiar with atmospheric scintillation, commonly called 'seeing'. Interestingly, this effect occurs within air on optical surfaces just as it does in the larger environment. The only requirement is for the optic to be different in temperature than the air. Traditionally, fans are used to cool the primary mirror toward the ambient temperature, but equilibration is not reached until after the environmental ceases cooling. This means that there will be a boundary layer of boiling air sitting between the sky and the mirror for most of the night. PlaneWave has proven that well placed "side-fans" will significantly reduce mirror-surface seeing effects, while further assisting in cooling. This is why the DeltaRho 350 features a total of 7 fans, with 3 in the backplate and 4 at the perimeter of the primary mirror.



New Rotator and Focuser

While designing the new DeltaRho 350 we also wanted to design a new focuser and rotator that would add even more flexibility to our systems. The goal was to create a faster, stronger, focuser and rotator system that had a thinner profile than the IRF90. Our new Series-5 stackable focuser and rotator have achieved just that for users of our CDK700 and smaller telescopes. Both the focuser and rotator offer a clear aperture of 5" and are designed to stack for users that require derotation. For those only needing focusing capabilities, the new focuser also occupies less backfocus, which means more room for imaging train components! On top of that, we have designed a new 5-wire bus communication box that controls the rotator and focuser, which includes M12 circular 5-wire threaded connector heads for environmental sealing.



DeltaRho 350 Backfocus = 5.651"

- 5-Series Focuser Thickness = 1.675"
- 5-Series Rotator Thickness = 1.105"
- 5-Series Focuser Travel = 0.65"
- Remaining backfocus of rotator & focuser halfway racked out = 2.546"

NEW ROTATOR

- Backfocus occupied: 1.105"
- Rotates up to 700 degrees between mechanical hardstops (+ or – 350 degrees from the center of travel).
- Speed: up to 15 degrees/second
- Clear aperture: 5"
- Weight capacity: 40lbs
- Weight: 5.5lbs

NEW FOCUSER

- Backfocus occupied: 1.675"
- Focuser travel range of 0.65"
- Clear aperture: 5"
- Weight capacity: 40lbs
- Weight: 6.5lbs

PlaneWave™ INSTRUMENTS

DeltaRho 350
SAMPLE ASTROPHOTOGRAPHY

Pinwheel Galaxy (M101)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in alt/az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
5 x 2-minute exposures per channel (Gain 100 and Offset 75)

Full Resolution Version
https://bit.ly/2S4LNqI

Trifid Nebula (M20)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in alt/az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
5 x 2-minute exposures per channel (Gain 100 and Offset 75)

Full Resolution Version
https://bit.ly/3xnTxmH

PlaneWave™ INSTRUMENTS

DeltaRho 350
SAMPLE ASTROPHOTOGRAPHY

Eagle Nebula (M16)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in Alt/Az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
10 x 2-minute Luminance and 5 x 2-minute exposures RGB (Gain 100 and Offset 75)

Full Resolution Version
https://bit.ly/3gAVxRS

Lagoon Nebula (M8)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in Alt/Az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
3 x 2-minute exposures per channel (Gain 100 and Offset 75)

Full Resolution Version
https://bit.ly/3iMk6O9

DeltaRho 350
SAMPLE ASTROPHOTOGRAPHY

Crescent Nebula (NGC6888)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in alt/az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
5 x 2-minute exposures per channel (Gain 100 and Offset 75)

Full Resolution Version
https://bit.ly/2TH9yW0

Markarian's Chain (NGC4435)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in alt/az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
5 x 2-minute exposures for L and 3 x 2-minue exposures for RGB (Gain 100 and Offset 75)

Full Resolution Version
https://bit.ly/3pZdFcn

PlaneWave™ INSTRUMENTS

DeltaRho 350
SPECIFICATIONS

OPTICAL DESIGN

Optical Design	Corrected Dall-Kirkham (CDK)
Aperture	350mm
Focal Length	1050mm (41.34 inch)
Focal ratio	f/3
Central Obstruction	56 % by diameter
Back Focus from Mounting Surface	5.6 inch (142.24mm)
Weight	46lbs (21 kg)
OTA Length	23 inch (584mm)
Optical Performance	4.9 micron RMS on-axis, 6.2 micron RMS at 23mm off-axis, and 7.6 micron RMS at 30mm off-axis
Telescope Cage	Carbon fiber truss poles with carbon fiber shroud
Optimal Field of View	60mm image circle

SECONDARY MIRROR

Diameter	190 mm (7.48 inch)
Material	Fused silica (Quartz)
Shape	Spherical
Coating	Enhanced aluminum - 96%

PRIMARY MIRROR

Optical Diameter	13.78 inches (350mm)
Outer Diameter	14.5 inches (468.3mm)
Shape	Prolate ellipsoid
Material	Fused silica (Quartz)
Coating	Enhanced aluminum - 96%

LENS GROUP

Diameter	110mm (4.33 inch)
Number of Lenses	Three
Coating	Broadband AR Coatings (less than .5% reflected from 400 to 700nm)

DeltaRho 350
SPECIFICATIONS

STANDARD FEATURES

Corrected Cassegrain	The corrected design yields a flat field optimized for astro-imaging.
Carbon Fiber Truss Design	Minimizes thermal expansion to limit focus shift due to changes in temperature.
Dovetail Expansion Joint	Allows for the difference in thermal expansion between carbon fiber and aluminum. The expansion joint allows the aluminum dovetail to expand and contract without stressing the carbon fiber truss.
Cooling Fans	Three fans at the backplate and four on the side help cool the telescope to ambient temperature. This helps the telescope to reach thermal equilibrium quickly. The fans are controlled by a computer if the optional Electronic Focus Accessory (EFA Kit) is purchased.
Dew Prevention Ready	For added dew prevention, the DR350 is internally wired with polyimide film heater pads and temperature sensors, ready to be controlled with the optional 5-Series Controller.

SHIPPING

Crated Shipping Weight	225lbs
Crate Width	31 inches
Crate Height	26 inches
Crate Length	53 inches

INCLUDES ACCESSORIES

OTA Cover	To protect the telescope optics.
PlaneWave Thumb Drive	Contains software and instructions for collimation and spacing the primary to secondary mirror.
24VDC Power Supply	Provides power for the fans (Not included for European orders).
Wrench Set (5812A35)	Standard hex wrenches (European orders only).

WHY PLANEWAVE

Company Overview

PlaneWave manufactures commercial off-the-shelf (COTS) 300mm, 350mm, 400mm, 500mm, 600mm, 700mm and 1,000mm ground based telescopes, and tracking-systems which, when combined with emerging sensors, can provide sensitivities that meet or exceed mission requirements.

Many of our telescopes are based on the revolutionary CDK [Corrected Dall-Kirkham] optical design developed by CTO, Dave Rowe. The CDK is coma free, has no off-axis astigmatism, and has a flat field. The CDK out performs the older RC design; is a lower cost telescope to manufacture and has a proven, field tested 11-year track record.

Our telescope mountings are agile direct-drive tracking systems. They are highly reliable and allow slew speeds of more than 50 degrees per second. Our mounts can meet requirements of >1,000,000 slews/year to affordably track orbital or deep-space objects without failure.

These telescopes and their mounts have been designed to simplify both remote-control and autonomous operation. This should ease creation of affordable and affordably operable world-wide SSA and optical-communication networks. Note that near the middle of the night, when LEO objects are in eclipse, the telescopes can also find and track objects in higher orbits (GPS and GEO). They can also be used as ground stations for free-space optical communication (laser-com).

Our telescopes, mirrors, mounts and motors are designed and manufactured by PlaneWave in its California and Michigan facilities. We are a small business and all employees are American citizens.

Core Capabilities

- PlaneWave management is experienced and has a proven track record of delivering on time and on budget.
- PlaneWave is a leader in developing products that are innovative, high quality and are designed in such a fashion that they are scalable to volume manufacturing.
- Our facilities utilize SolidWorks and custom software tools, state of the art CNC, as well as 3D printing to design and realize our products.
- PlaneWave employs a pool of very talented young innovative mechanical, electrical and software engineers. Our reputation allows us to pick from the best.

Key Technologies

- PlaneWave has developed a variety of motion control algorithms, astrometric analysis software, pointing analysis and correction software, and control system architectures that significantly enhance performance of our gimbal systems.
- PlaneWave's vertical integration, including in-house design and manufacture of our gimbals' motors, allows minimized cost and maximized performance through motor design optimization and right-sizing for both our gimbals and their intended payloads.

Company HISTORY

PlaneWave Instruments is a privately held company headquartered in Adrian, MI and was founded in 2006 by Richard Hedrick and Joseph Haberman. It operates design and manufacturing facilities in California and Michigan. Through the leadership of its founders and CTO David Rowe, the company developed and championed the CDK (Corrected Dall-Kirkham) telescope, a revolutionary new optical system.

In addition to consumer products, PlaneWave makes a full line of observatory class telescope mounts, and the CDK and Ritchey-Chrétien (RC) telescope line from 12.5" to 1 meter apertures. The company produces Off-The-Shelf high-quality products at unprecedented value. The products are used by universities, research centers and aerospace companies with 60 CDK700s (0.7 meter aperture) and 15 PW1000 (1 meter aperture) telescopes installed as of 2020.

Most recently, PlaneWave has begun offering standalone, direct-drive tracking-systems, compatible with both our CDK optical-systems and many third-party manufactured telescopes and instrument packages. Building upon the technology, manufacturing knowledge, and software that were necessarily developed for the CDK700 and CDK1000 observatory telescopes, our L-Series mounts offer the same exceptional performance, robust reliability, and comfortable ease of use.

With 8Mhz encoders and direct-drive actuation, resulting in slewing speeds in excess of 100 degrees/second, motion speeds of the system will typically be imposed by the telescope's or instrument's mechanics. We expect these capabilities, at our mounts' respective price-points, will be game-changing for a wide variety of researchers and commercial users.

PlaneWave Instruments is also prepared to offer our engineering services and manufacturing expertise to the most demanding clienteles' needs for innovative and custom solutions.