# SOLA Elan™:
## Performance Every Progressive Wearer Can Count On

By Darryl Meister, ABOM

*SOLA Elan is the latest generation progressive lens by SOLA, a brand known for delivering wearer satisfaction. Based on an award-winning lens design platform, SOLA Elan combines a lifestyle-based lens design with Physiologically Mapped Optics in order to ensure exceptional utility and wearer satisfaction, regardless of the wearer's type of refractive error or stage of presbyopia. SOLA Elan achieves next-generation optical performance by utilizing a variety of sophisticated features in a lens design that is easy to dispense for eye care professionals and easy to wear for presbyopes. SOLA Elan HDv, a fully customized free-form version, completes the product offering.*

## Limitations of Conventional Progressive Lenses

In order for human beings to demonstrate peak performance during the variety of tasks that we perform daily, from walking to reading, our visual system must adapt seamlessly to the visual requirements of a wide range of viewing tasks. When in motion, for instance, our visual system must process a dynamically changing flow of information while attempting to fixate and judge spatial relationships between objects in our expansive visual field. When performing many critical viewing tasks such as reading, on the other hand, our visual system relies on stable, sharp visual acuity and high contrast over a fairly narrow region of our visual field.

Unfortunately, the optical limitations characteristic of progressive lenses serve to limit visual performance during many viewing tasks. Regions of unwanted astigmatism both from optical aberrations and from the "blending" zones of the progressive lens surface restrict the fields of clear vision. Rapid changes in power and distortion in the periphery of the lens disrupt comfortable, accurate binocular vision. Furthermore, the balance among the central viewing zones and the quality of the peripheral optics are often unsuitable for progressive lens wearers with different types of *ametropia* (refractive error) and at different stages of *presbyopia* (loss of up-close focusing ability).

Given the typical visual demands of many wearers, conventional progressive lenses often offer a poorly conceived balance between the distance zone and the near zone of the lens design. Moreover, conventional progressive lenses often employ the same basic lens design for every wearer, which is essentially scaled to each base curve and addition power. This rudimentary approach to lens design can result in compromised visual performance for wearers with different refractive errors or addition powers (Figure 1).

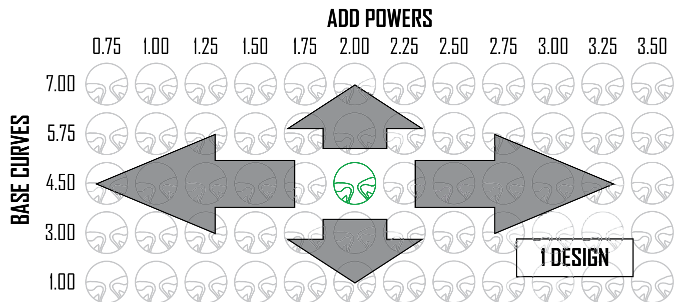


*Figure 1. Conventional progressive lenses often offer a single or "mono" lens design that is "scaled" to each base curve and addition power, which can result in unnecessarily compromised performance for many wearers, particularly as the magnitude of their refractive error or the degree of their presbyopia increases.*

SOLA ushered in a new era of progressive lens performance with the launch of SOLAOne, an award-winning* progressive lens design that achieved truly versatile performance by offering a patented balance of visual utility across the most common viewing tasks.[1] The exceptional performance and wearer satisfaction of SOLAOne set a new standard for general-purpose progressive lenses. Now, the newest progressive lens by SOLA promises to deliver even greater versatility and performance for even more progressive lens wearers.

The product of years of ongoing research into the visual lifestyle demands of presbyopes, SOLA Elan represents the latest-generation progressive lens by SOLA. SOLA Elan extends the award-winning performance of SOLAOne by combining proven features with even wider viewing zones and a more advanced Design by Prescription™ strategy referred to as Physiologically Mapped Optics™. SOLA Elan reflects the perfect integration of the visual lifestyle and physiology of the progressive lens wearer with the actual lens design.

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* Winner of the 2004 Optical Laboratory Association's *Award of Excellence in Lens Design*.

SOLA

# Anatomy of a Lifestyle-Based Lens Design

Presbyopes engage in a wide variety of visually demanding tasks throughout the day. Certain viewing tasks, such as driving, require clear far-away vision with undistorted peripheral vision in order to maintain comfortable vision during frequent head and eye movements. Tasks such as reading and writing require clear up-close vision that can be obtained without uncomfortable postural adjustments. The optical limitations of conventional progressive lenses, however, often result in compromised visual utility that can actually reduce the performance of presbyopes in many of these tasks, resulting in a lower "quality of life" compared to their performance with pre-presbyopic vision.

Due to the physical limitations of smoothly blending the different curves of the lens surface into each other, progressive lens wearers must tolerate *unwanted astigmatism* in the lateral regions of the lens to either side of the central distance, intermediate, and near viewing zones. This unwanted astigmatism is perceived both as blur that can limit the utility of the central viewing zones and as geometric distortion that can disrupt vision and induce physical discomfort similar to vertigo. Although it is possible to increase the utility of progressive lenses for certain viewing tasks by widening one or more of the central viewing zones, this will cause the unwanted astigmatism flanking the viewing zones to increase in severity, thereby reducing the utility of the lens for other viewing tasks.

Older-generation progressive lenses frequently offered wide distance and near viewing zones at the expense of peripheral quality. These "hard" lens designs suffered from high levels of blur, image swim, and distortion in the periphery, which made the lenses unsuitable for active viewing tasks and often uncomfortable to wear. Although the peripheral balance has been improved in modern lens designs, many conventional progressive lenses offer excess far vision utility at the expense of sufficient reading utility, or excess reading utility at the expense of far vision utility. Consequently, the perfect balance of optical performance and utility is seldom realized (Figure 2).

The size of central viewing zones must be carefully balanced against the quality of the periphery to offer the wearer sufficient visual utility for sustained viewing tasks without unnecessarily compromising visual comfort during active viewing tasks. The relative sizes of the distance, intermediate, and near viewing zones must also be carefully balanced in order to offer the wearer the most utility across the broadest range of critical viewing tasks. Achieving perfectly balanced visual utility relies on extensive research into the lifestyles and visual habits of presbyopes.

Fortunately, SOLA Elan builds on the extensive vision research used to develop the highly successful SOLAOne design platform. To determine the optimum balance between the distance, intermediate, near, and peripheral zones of the lens, vision scientists first assessed the visual habits of hundreds of presbyopes. A lifestyle profile was then created for each presbyope indicating the most frequent viewing tasks associated with their lifestyles. The size and utility of each zone of the lens was then carefully defined by the relative contribution of each viewing task to the lifestyles of these presbyopes. For SOLA Elan, this approach was further refined using additional wearer data, and new optical design tools were employed to enlarge the viewing zones in order to deliver even greater utility to a broader number of progressive lens wearers (Figure 3).

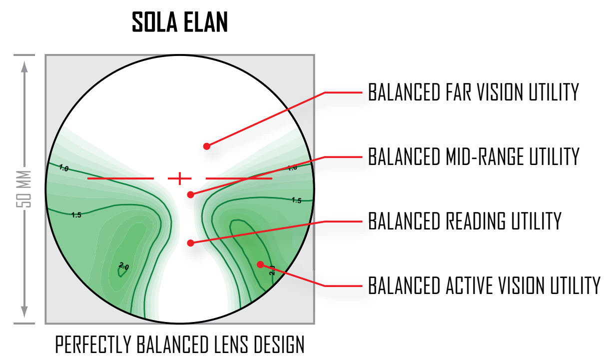
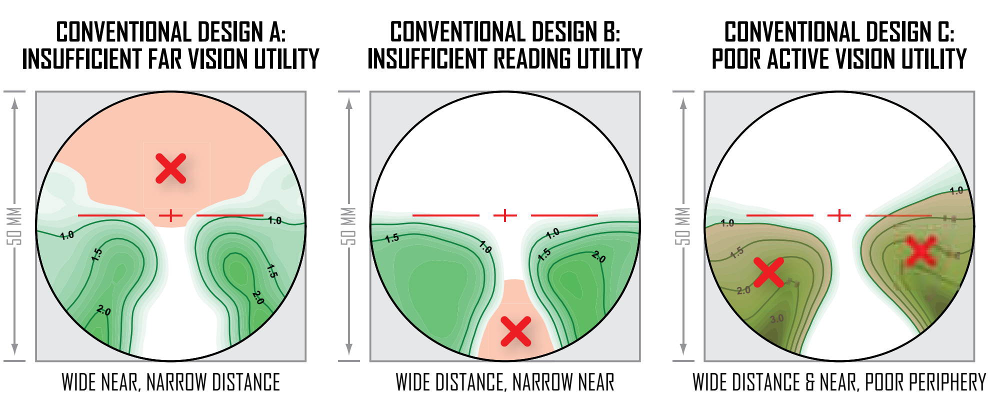



*Figure 3. Unlike conventional lenses, SOLA Elan relies on a carefully perfected and proven balance between the distance, intermediate, near, and peripheral zones.*

*Figure 2. Conventional progressive lenses often rely on lens design choices that do not offer the optimum balance of visual utility for many wearers, resulting in reduced performance for the wearer during far-away viewing tasks, up-close viewing tasks, or active viewing tasks.*



## Physiologically Mapped Optics™

Progressive lens wearers are as varied as the tasks that they perform throughout the day. The optimum design of a progressive lens is in no small way influenced by the physiology of the visual system of the actual wearer. Unfortunately, no single progressive lens design will deliver optimum comfort and utility for wearers with different types of ametropia—myopia, emmetropia, or hyperopia—or at different stages of presbyopia—emerging, experienced, or advanced. The most versatile progressive lens design for some presbyopes will not be the most versatile lens design for many others.

With this in mind, lens designers at SOLA first pioneered Design by Prescription™ technology over ten years ago to manipulate the basic design of the progressive lens for different prescription ranges and addition powers.[2,3] SOLA Elan employs the latest generation of this state-of-the-art technology: *Physiologically Mapped Optics*. By distributing power and unwanted astigmatism based on the physiological requirements of the wearer's visual system, Physiologically Mapped Optics maintains SOLA Elan's carefully balanced utility for all progressive lens wearers, regardless of their type of refractive error or their stage of presbyopia.

Although conventional progressive lenses utilize a single lens design that is essentially "scaled" to each base (front) curve and addition power, SOLA Elan starts with a lens design that has been specifically tailored to each prescription range and addition power (Figure 4). The optical configuration of the lens design corresponding to each base curve and addition power combination is carefully mapped to the physiological and visual lifestyle requirements of the wearer in order to create an array of progressive lens designs corresponding to a "two-dimensional optical mapping space" (Figure 5).

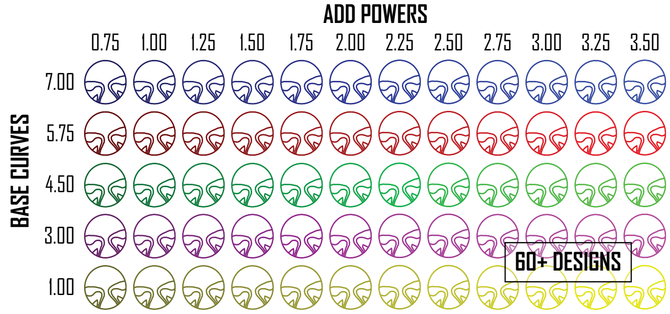



*Figure 4. Physiologically Mapped Optics starts with a distinct lens design for each base curve and addition power combination, resulting in 60 or more lens designs.*

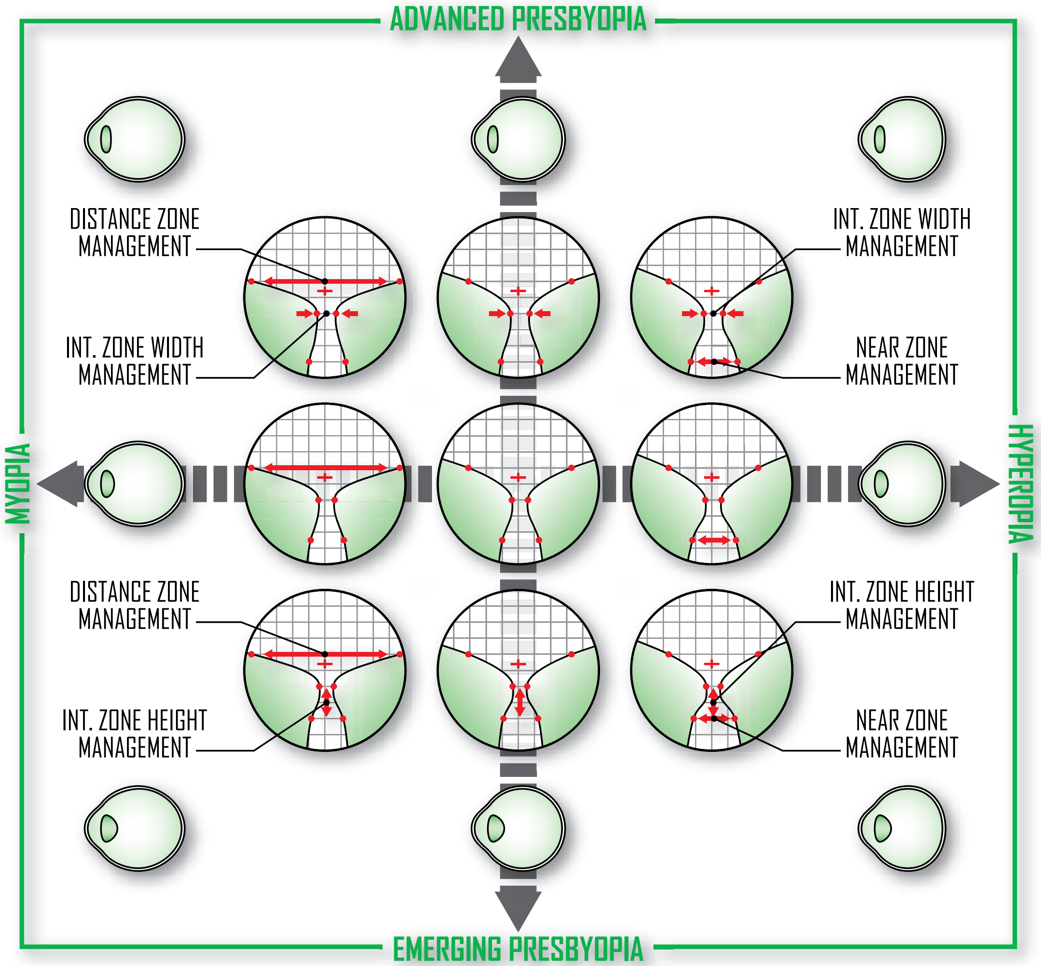



*Figure 5. Physiologically Mapped Optics starts with a matrix of distinct progressive lens designs that have been individually tailored to the specific physiological requirements associated with different types of ametropia and different stages of presbyopia, resulting in a two-dimensional optical mapping space of lens design permutations with the wearer's type and magnitude of ametropia representing the horizontal axis and the wearer's stage of presbyopia representing the vertical axis.*

## Physiological Mapping for Ametropia

In order to maintain truly balanced viewing zones that deliver the most utility across the broadest range of viewing tasks, the physiology of the visual system of the actual wearer must be considered. Due to the effects of lens magnification, lens aberrations produced at "off-axis" viewing angles, and the particular visual lifestyle habits associated with different types of ametropia, the ideal configuration of the viewing zones of a progressive lens design varies as a function of the type and magnitude of the refractive error of the wearer. Consequently, the ideal progressive lens designs for *hyperopes* (with farsightedness), *emmetropes* (with little or no refractive error), and *myopes* (with nearsightedness) can differ significantly.

Physiologically Mapped Optics results in a series of distinct progressive lens designs that compensate for the physiological differences between human eyes with different types of ametropia (Figure 6). The visual system of the myopic eye is stronger than necessary, requiring a minus-powered lens to correct its optics. "Minus" lenses are made using flatter *base* (front) curves than comparable plano-powered lenses for emmetropes. The visual system of the hyperopic eye, on the other hand, is weaker than necessary, requiring a plus-powered lens to correct its optics. "Plus" lenses are made using steeper base curves than comparable plano-powered lenses.

Experience dictates that myopes are frequently more critical of their far-away vision through progressive lenses compared to emmetropes. In fact, many myopes can read comfortably without their progressive lenses, while emmetropes can often drive without them. Many progressive lens designs, however, restrict the field of clear far vision with minus lenses. Optical aberrations that occur in the periphery of minus lenses exacerbate the inherent astigmatism of the progressive lens surface. Excess addition power in the periphery of progressive lenses also results in blur through an under-correction of myopia. The progressive lens designs utilized on the flatter base curves of SOLA Elan have been specifically tailored for the visual requirements of myopes by incorporating a wider distance zone.

Hyperopes, on the other hand, are especially reliant on progressive lenses to read. In fact, many hyperopes can see clearly at distance without their progressive lenses. Due to the magnification of plus lenses, however, the field of clear vision through the viewing zones of progressive lenses is significantly reduced compared to plano and minus lenses. This is particularly problematic for the near zone, which is already significantly narrower than the distance zone. The SOLA Elan lens designs utilized with the steeper base curves have been specifically tailored to the visual requirements of hyperopes by incorporating a wider near zone.

Because the interaction between the "off-axis" aberrations in plus lenses and the astigmatism and excess addition power in the periphery of the progressive lens surface is less detrimental compared to minus lenses, the size of the distance zones as perceived by actual hyperopic and myopic wearers remains similar (Figure 7). Since SOLA Elan utilizes cosmetically flattened lens profiles in order to obtain thinner and lighter lenses, the asphericity of each base curve has been optically fine-tuned to each prescription range. Additionally, the inset of the near zone and progressive corridor has been calculated based on the prismatic effects introduced by each prescription range when the eyes converge to read.

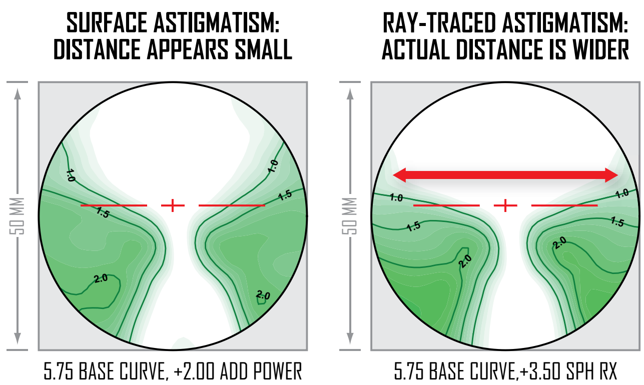
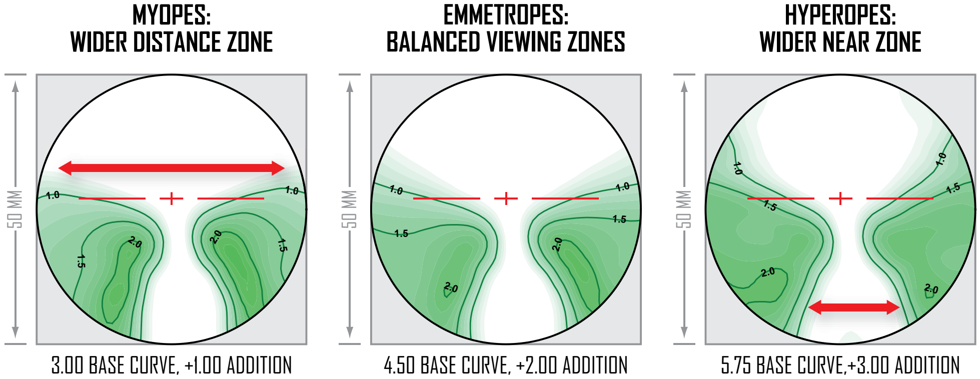



*Figure 7. Due to the interaction of off-axis aberrations with the astigmatism of the lens surface, the ray-traced distance zone perceived by the wearer is actually larger.*

*Figure 6. As these contour plots of surface astigmatism indicate, Physiologically Mapped Optics employs a wider distance zone for myopes and a wider near zone for hyperopes—compared to the lens design configuration utilized for emmetropes—in order to maintain the perfect balance of visual utility for wearers, regardless of their type of refractive error.*



# Physiological Mapping for Presbyopia

As the human eye ages, it progressively loses the ability to *accommodate* or to focus on objects up-close, which results in a condition known as *presbyopia*. Physiologically Mapped Optics results in a series of unique progressive lens designs that compensate for the physiological differences between human eyes at different stages of presbyopia (Figure 8). The visual system of the *emerging* presbyobic eye has an adequate reserve of accommodation for mid-range viewing distances compared to *experienced* presbyopes, requiring only a weak addition power for up-close viewing distances. The visual system of the *advanced* presbyopic eye, on the other hand, does not have sufficient accommodation for either mid-range or up-close viewing distances, requiring a stronger addition power.

Emerging presbyopes with low addition powers are accustomed to unrestricted access to near vision through single vision lenses. Because of an adequate reserve of accommodation and a lower addition power, these presbyopes can also see objects at mid-range distances clearly through either the distance zone or near zone of the lens. Therefore, a large intermediate zone is less critical. The SOLA Elan lens designs utilized with the lower addition powers have been specifically tailored to the visual requirements of emerging presbyopes by incorporating a shorter intermediate zone with more easily accessible reading utility (Figure 9).

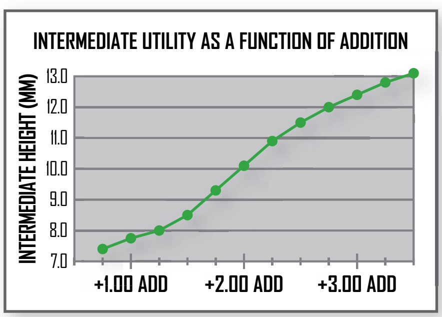



*Figure 9. SOLA Elan utilizes a shorter intermediate zone in lower addition powers to provide a more easily accessible near zone.*

Advanced presbyopes with higher addition powers, on the other hand, have lost their ability to focus on both up-close and mid-range objects. As a consequence of the inherent mathematical limitations of progressive lens surfaces, however, the intermediate and near zones of the lens become more narrow and the unwanted astigmatism in the periphery becomes greater as the addition power of the lens design increases. Advanced presbyopes must therefore tolerate higher levels of distortion in conventional progressive lenses as well as reduced mid-range vision utility when they need it most.

These optical effects can be offset, however, by increasing the corridor length of the lens design, or the distance over which the addition power must change. The progressive lens designs utilized with the higher addition powers of SOLA Elan have been specifically tailored to the visual requirements of advanced presbyopes by incorporating a longer intermediate that is also wider compared to similar progressive lenses that utilize a single, scaled lens design for every addition power (Figure 10). Additionally, the inset of the near zone and progressive corridor has been calculated based on the near and mid-range reading distances associated with each addition power to ensure proper binocular alignment of the viewing zones.

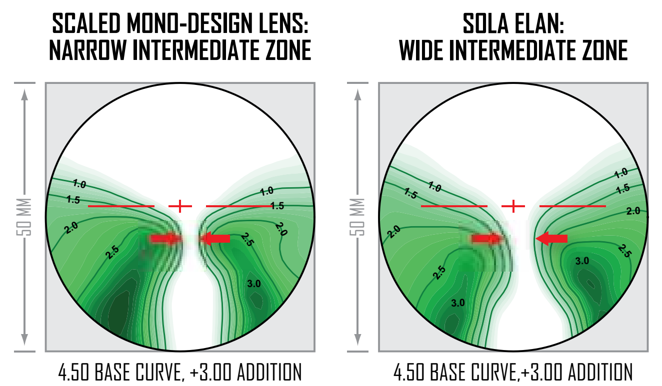
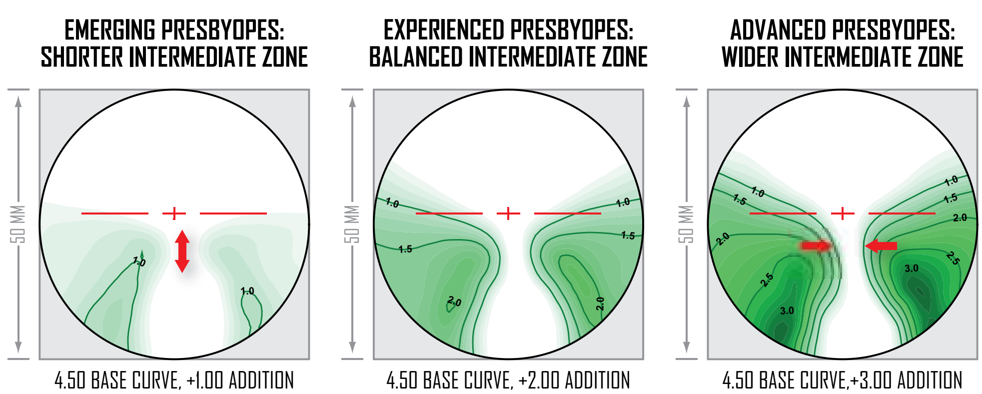



*Figure 10. Unlike conventional "mono" progressive lens designs, which typically suffer from significantly reduced mid-range utility and greater peripheral blur in higher addition powers, SOLA Elan offers a longer, wider intermediate zone.*

*Figure 8. As these contour plots of surface astigmatism indicate, Physiologically Mapped Optics employs a shorter intermediate zone with more accessible reading vision for emerging presbyopes and a longer, wider intermediate zone with more mid-range utility for advanced presbyopes—compared to the lens design configuration utilized for experienced presbyopes with moderate addition powers—in order to maintain the perfect balance of visual utility for wearers, regardless of their state of presbyopia.*



## Available with High Definition Performance

Due to the limitations of traditional, factory-molded lenses, residual optical aberrations compromise the optical performance of many prescriptions and positions of wear. The optical limitations of traditional lenses are especially problematic for progressive lenses, since residual optical aberrations such as *oblique astigmatism* interact with the unwanted astigmatism across the progressive lens surface. These optical interactions can potentially degrade the clarity of the central viewing zones of the lens, while causing the viewing zones to shrink or even become distorted in shape (Figure 11).

Each base curve of traditional, semi-finished progressive lens design can only be fully optimized for a single prescription and a single set of fitting parameters, referred to as the *position of wear*. Typically, the ideal lens design is calculated for an average sphere power located near the center of the prescription range associated with each base curve using a set of average values for vertex distance, pantoscopic tilt, and frame wrap angle. For other prescription combinations or positions of wear, the optical performance of the lens design begins to deteriorate because of uncorrected optical aberrations. Many wearers must therefore tolerate poorer vision quality and reduced visual utility with traditional progressive lenses (Figure 12).

Unlike traditional progressive lenses, however, SOLA Elan HDV's lens design is not optimized or calculated in advance for a handful of base curves or a single position of wear. SOLA Elan HDv is fully customized in "real time" for the wearer's exact prescription requirements using SOLA's exclusive optical design software engine and patented[4] free-form technology. This proprietary optical design engine utilizes sophisticated computer ray tracing and complex optimization algorithms in order to calculate and to refine the optics of the lens design as perceived by the actual wearer.

A unique back-surface progressive lens design that has been fully customized to the exact prescription and fitting requirements of each wearer is dynamically generated. The fully customized lens design is then accurately replicated onto a lens blank using extremely precise free-form surfacing technology. This state-of-the-art optical optimization and lens production process custom-tailors the optics of each lens to ensure that the intended optical performance of the SOLA Elan lens design is preserved for every wearer, regardless of his or her unique prescription or fitting requirements. As a result, SOLA Elan HDv progressive lenses will offer up to 50% larger fields of clear vision compared to traditional progressive lenses (Figure 13).

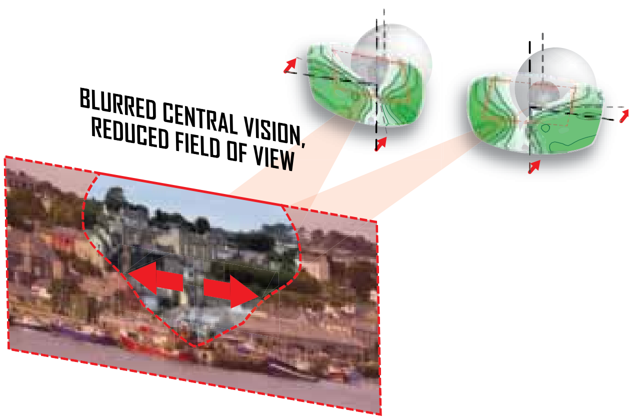



*Figure 12. Traditional progressive lenses are designed for a handful of "average" prescription sphere powers in an "average" position of wear, which can result in compromised optical performance and reduced utility for many wearers.*

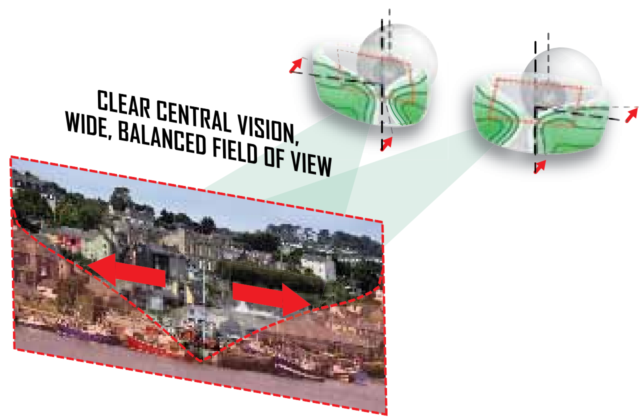
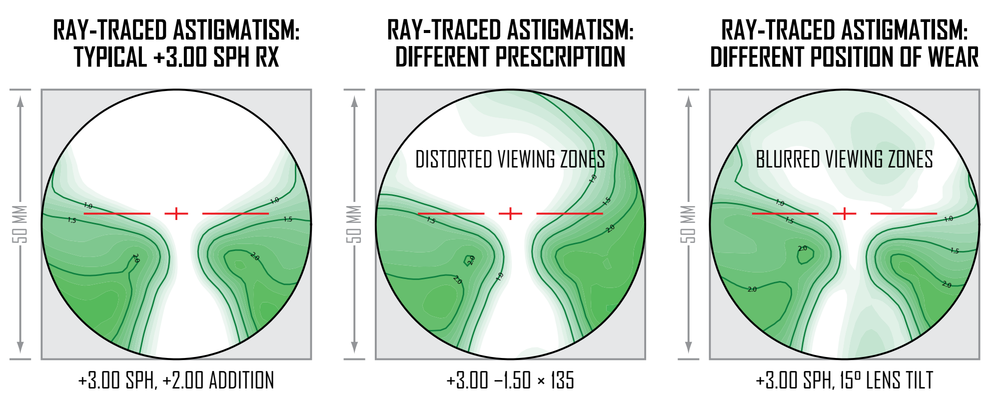



*Figure 13. Unlike traditional progressive lenses, SOLA Elan HDv is customized for the wearer's exact prescription requirements and position of wear, which ensures the widest, clearest fields of vision possible.*

*Figure 11. As these ray-traced contour plots of the optical astigmatism experienced by the actual wearer indicate, the specific prescription requirements and fitting geometry of a given progressive lens can significantly impact the optical performance of the lens design.*



## Morphing Generation™ Technology

Frame styles range in size from extravagant fashion sunwear to diminutive rimless mountings. In smaller frame styles, progressive lens designs with a relatively short corridor length are necessary in order to maintain sufficient reading utility; otherwise, much of the near zone may be cut away. Unfortunately, as the corridor length of a progressive surface becomes shorter, unwanted astigmatism increases more rapidly, since the progressive optics are essentially "compressed." Progressive lenses with shorter corridor lengths will tend to have higher levels of peripheral astigmatism, narrower viewing zones, and less mid-range utility. The length of the progressive corridor should therefore be no shorter than necessary.

The practical limitations of mass-producing lenses, however, dictate that semi-finished progressive lenses are only made available in one or two corridor lengths. Although "standard" progressive lenses with long corridor lengths and "short-corridor" progressive lenses offer sufficient visual utility at the extremes of this broad range of frame sizes, the majority of frames fall somewhere between these two extremes. Standard lens designs may not offer sufficient reading utility in these frames, whereas short-corridor lens designs may compromise optical performance unnecessarily (Figure 14).

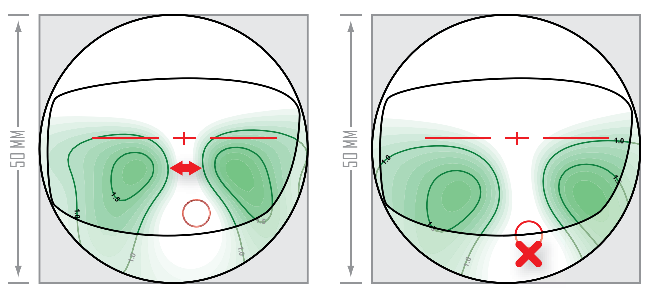



*Figure 14. As these contour plots of unwanted surface astigmatism within a frame of moderate size indicate, many wearers must tolerate either insufficient reading utility or unnecessarily small viewing zones with greater peripheral astigmatism.*

SOLA Elan HDv employs SOLA's patented[5] Morphing Generation™ technology, which manipulates the size and shape of the distance, intermediate, near, and peripheral zones of the lens design in "real time." By combining sophisticated computer interpolation with curvature vector mapping algorithms that can literally expand or contract the various zones of the lens as needed, the overall geometry of the progressive lens design can be modified on the fly to maximize the performance of the lens for each wearer. This exclusive technology is similar to the software used to create the computer-generated special effects often seen in films and television.

Morphing Generation technology allows SOLA's free-form optical design engine to match the ideal corridor length and viewing zone sizes of the lens design to the fitting height and frame size selected by each wearer (Figure 15). The ideal balance between reading utility and the size of the remaining zones of the lens design is therefore achieved for every wearer, down to a minimum fitting height of only 14 mm. Each SOLA Elan HDv lens is engraved with a code to identify the unique lens design associated with the specified fitting height.

| Fitting Height | 14-17 | 18 | 19 | 20 | 21 | 22+ |
|---|---|---|---|---|---|---|
| Engraved Code | V4 | V5 | V6 | V7 | V8 | V9 |

Although many free-form progressive lenses rely on placing some or even all of the progressive addition optics on the front surface of the lens using traditional molding, each SOLA Elan HDv lens design is directly surfaced onto the lens blank using precision free-form manufacturing. This ensures accurate replication of the progressive lens design. Placing the progressive optics on a single surface also eliminates the possibility of misalignment between the optics of the front and back surfaces. Moreover, the use of back-surface progressive optics maximizes the fields of clear vision by placing the viewing zones closer to the eyes, while minimizing unwanted magnification effects, such as *skew distortion* and *image swim*.

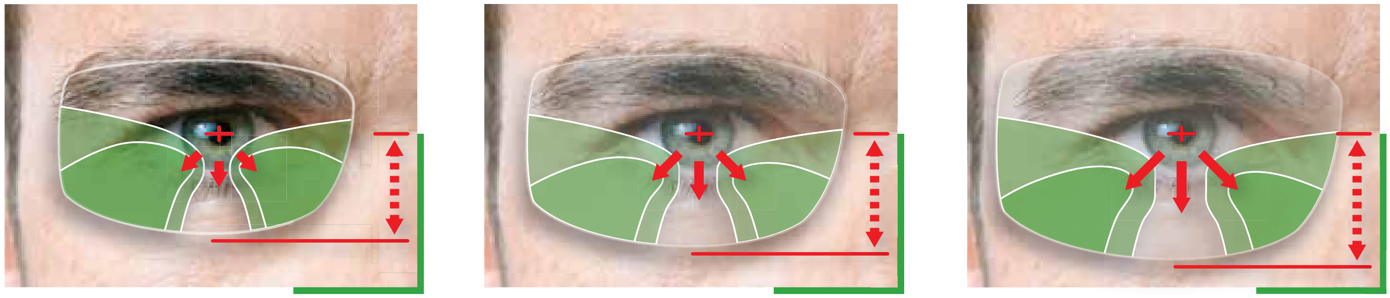



*Figure 15. SOLA's patented Morphing Generation technology expands or contracts the corridor length and viewing zones of the SOLA Elan HDv lens design based upon the wearer's selected frame size and fitting height in order to maximize optical performance and reading utility, regardless of frame size.*

# Next-Generation Optical Performance by SOLA

SOLA Elan is the latest result of an award-winning approach to progressive lens design. SOLA Elan has been uniquely engineered to deliver superior performance across the full range of daily visual tasks faced by today's demanding presbyopes. Further, using Physiologically Mapped Optics, this performance has been fine-tuned for the visual lifestyle habits and physiological characteristics of all presbyopes, regardless of their type of ametropia or state of presbyopia. Newly developed optical design tools and a variety of unique design features result in a progressive lens that delivers perfectly balanced visual utility (Figure 16):

1. A larger distance zone ensures better utility in the most common far-away viewing tasks.
2. A larger near zone ensures better utility in up-close viewing tasks in a wide range of frames.
3. A generous intermediate zone with a carefully designed power profile ensures better utility in mid-range viewing tasks.
4. A softer periphery that has been optimized for lower image swim ensures better utility in active viewing tasks.
5. A more binocularly balanced lens design ensures better utility and more comfortable binocular vision in all viewing tasks.

Although SOLA progressive lenses are designed with versatile performance and dispensing simplicity in mind, SOLA Elan also relies on the most advanced optical design tools currently available. Optical performance and visual utility are maximized through a variety of sophisticated design features that are characteristic of the most advanced progressive lenses from Carl Zeiss Vision:

1. Point-by-point optical optimization for the position of wear ensures wider, clearer fields of vision.
2. Binocular optical design and variable near insets provide better binocular alignment and fusion between right and left lenses.
3. Cosmetically-flattened, aspheric lens profiles result in flatter, thinner, and lighter lenses.

SOLA Elan's next-generation performance is the product of the marriage between proven optical design principles, extensive vision science, and advanced design features. The resulting lens design is uniquely responsive both to the wearer's visual situation and to daily activities. Wearers can be confident that the quality of performance will remain remarkably consistent across all visual activities. Eye care professionals can be confident that this utility will be extended to all wearers, regardless of vision condition or stage of presbyopia.

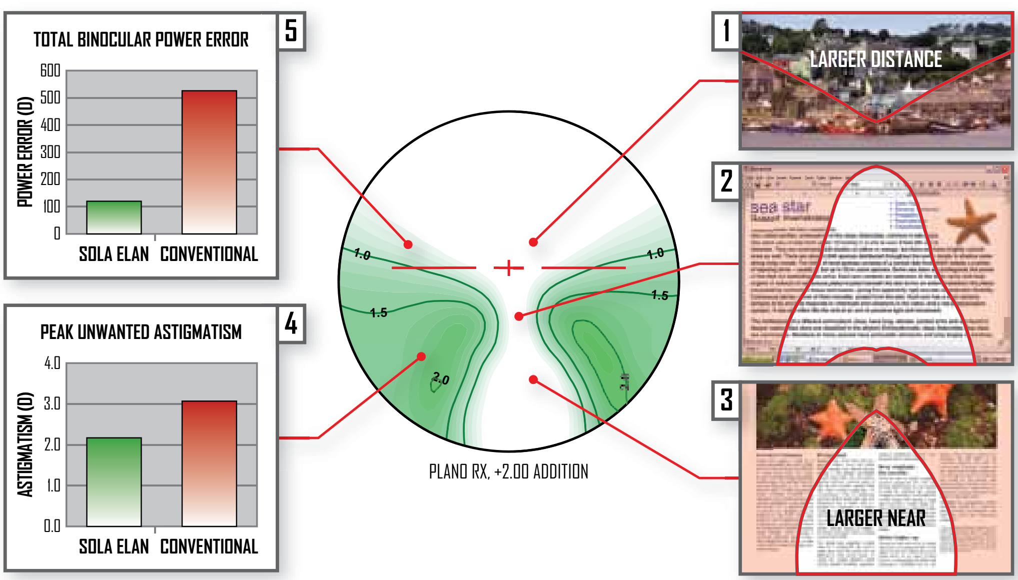



*Figure 16. SOLA Elan delivers perfectly balanced utility and wearer satisfaction through a number of lens design features that reflect an emphasis on the most common visual lifestyle demands of today's progressive lens wearers.*

1. Miller A. and Varnas S. "Balanced progressive lens." US Patent 7 066 597; 2005.
2. Morris M. and Barkin E. "Progressive lens elements and methods for designing and using same." US Patent 5 861 935; 1999.
3. Morris M. and Barkin E. "Progressive lens elements and methods for designing and using same." US Patent 6 074 062; 2000.
4. Hof A. and Hanssen A. "Spectacle Lens with Spherical Front Side and Multifocal Back Side and Process for Its Production." US Patent 6 089 713; 2000.
5. Fisher S. and Varnas S. "Method of designing progressive lenses." US Patent 7 344 245; 2005.

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Product designed and manufactured using Carl Zeiss Vision technology. US Patent 6,089,713. Other patents pending.
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