

## 20/20 Immersive Display System Based on Eye Tracking

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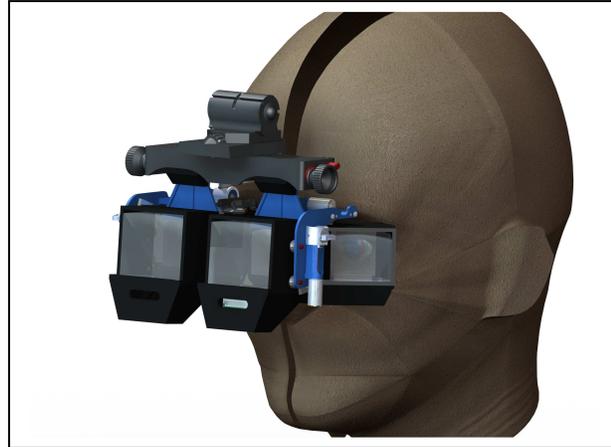
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**Command: NAVAIR**

**Topic: N07-041**

### PROBLEM STATEMENT

Military aircraft simulators, such as those used for the advanced next generation strike fighter aircraft require a large optical field of view in order to properly present the likeness of view from a cockpit window. Both eye motion and head motion are naturally used to center the operator's foveal region of high resolution upon objects of interest. At the same time, peripheral vision is critical for determining flight orientation and position within flight formations, and for noticing whether hostile activity is engaged in the vicinity of the aircraft. Both high resolution and wide peripheral vision must be supplied by the simulator. Currently, many flight simulators are based on projection screens arranged in a generally hemispherical globe or faceted surface around the simulated cockpit. Typically, a series of separate projectors are aligned such that the video panels or projections overlap to give the illusion of a continuous image. The systems currently in use do not offer 20/20 visual experience, as the total number of pixels required to do so would be enormous. As a result, resolutions on the order of 20/60 to 20/80 are common in current simulators. While certainly useful, the current state-of-the-art simulators can not accurately replicate the human visual experience of a real flight profile.

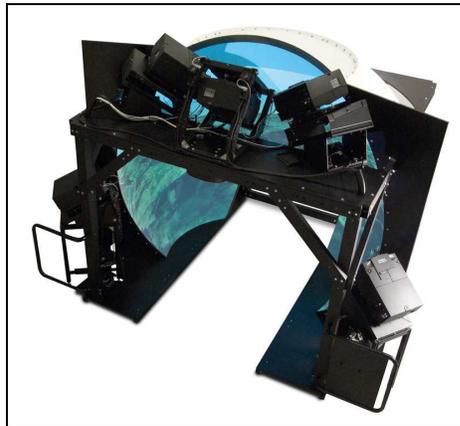
What is needed is a flight simulator display system which provides 20/20 visual acuity in at least a foveal region of view directed along the pilot's line of sight. By taking advantage of the fact that the human eye achieves peak resolution within only a small angular region, a cost-effective display system can be made which integrates a small number of high resolution displays with an eye-tracking system in a closed loop control scheme which keeps the high resolution imagery locked to the direction of the user's gaze.

## WHO CAN BENEFIT?

The beneficiaries of the advanced simulation technology developed under this SBIR effort includes all military aviators as well as all commercial pilots. Within the military community, the advanced next generation strike fighter is intended to be the primary beneficiary. The technology has a significant expansion capability to also be useful in high-end virtual reality fields such as medical imaging, geological surveys, and advanced industrial design.

## BASELINE TECHNOLOGY

Currently, many flight simulators are based on projection screens arranged in a generally hemispherical globe or faceted surface around the simulated cockpit. Typically, a series of separate projectors are aligned such that the video panels or projections overlap to give the illusion of a continuous image. The systems currently in use do not offer 20/20 visual experience, as the total number of pixels required to do so would be enormous. As a result, resolutions on the order of 20/60 to 20/80 are common in current simulators.

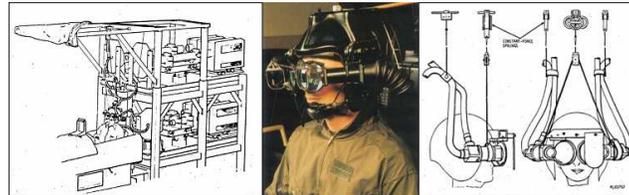


*Current Art: Dome Projector*

As shown in the figure above, a typical simulator system is comprised of a screen and an array of projectors. A typical price for a single HDTV projector is on the order of \$63,000 and thus the cost of the whole system can easily exceed \$200,000.

The SBIR topic calls for the creation of an immersive, wide field of view head-mounted display system which offers a moveable, tracked "foveal" region such that no matter where in the field the eye is looking, the resolution in the line of sight will be eye-limited with 20/20 Snellen acuity. The concept is that a single high-resolution video frame matched to the eye's natural region of best resolution can be slaved to the operator's line of sight, such that the peripheral video system can operate with much lower pixel resolutions and yet still provide a natural feel to the scene. The benefits from this approach could be significant compared to the more conventional method of tessellating ("stitching") together multiple flat panels with enough pixels to cover the entire visual field with high resolution rendering.

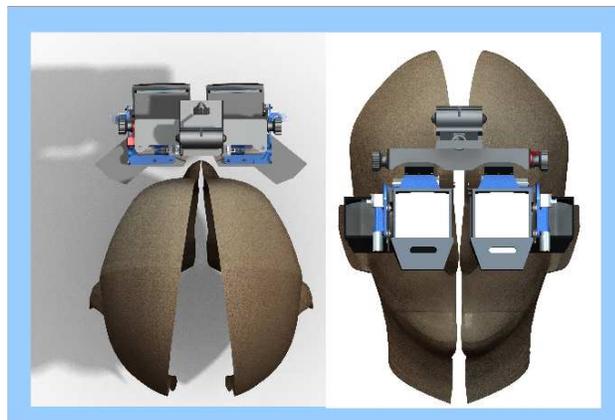
The overall concept for integrating such as display system has been conceived at least as far back as 1981, when CAE Systems began work on the Fiber-Optic Helmet Mounted Display (FOHMD). This system used large projectors and fiber imaging bundles to relay both an immersive wide FOV as well as a high resolution Insert FOV through the Pancake Window optics of the display. The system is very large, and requires springs to offset the head-mounted weight. The size, weight, cost, and complexity of the system has apparently prevented any commercialization.



*CAE Systems "Fiber-Optic HMD" Featured An Insert-FOV, But Suffered Enormous Size & Weight*

## TECHNOLOGY DESCRIPTION

The OASYS solution integrates the latest state-of-the-art SXGA format (1280x1024 pixel) Organic Light Emitting Diode (OLED) panels into a panoramic head-mounted system which provides an immersive, full color 30° x 130° field of vision with a high resolution "foveal insert" section of video spanning approximately 13° x 16°. The insert section contains micro-motors which position the line of sight to match the user's gaze direction within roughly a 30° x 40° region. The position feedback is via closed loop system coupled to an integrated commercial-off-the-shelf (COTS) eye tracker system. The system video interface is HDMI-compatible to accommodate various HDTV standard equipment. Additionally, the novel eyepiece design permits a see-through capability which enables the current dome simulator to be used to augment the "out the window" (OTW) viewing sensation.



*OASYS Foveal-Tracked Head Mounted Display*

The OASYS solution is a radical departure from the baseline dome technology in use today, because the new development is entirely a head-mounted concept. And unlike previous efforts for head-mounted system such as the FOHMD, the OASYS system is much lighter in weight and smaller in size. The modularity of the system also allows performance to be tailored to include monocular or binocular operation, removal of either the wide field or the foveal insert mechanisms, etc., such that a variety of low-end and high-end simulation tasks can be carried out at reasonable cost. Ultimately, the OASYS system can lead to a "simulator in a briefcase" solution which is completely field portable.

Feature	Dome Simulators	FOHMD System	OASYS System
20/20 Resolution	No	Yes	Yes
Modularity	Yes	No	Yes
Head-Mounted	No	Yes	Yes
Field-Portable	No	No	Yes
Full OTW Scene	Yes	No	No
Cost	High	Very High	Moderate/Low

*Feature & Benefit Table*

## **CURRENT STATE OF DEVELOPMENT**

The Technology Readiness Level (TRL) of this effort is estimated to be Level 3 at the mid-way point of the Phase II effort. The design effort is concluded, all critical components have been identified, and fabrication of the bench demonstrator has begun. (*TRL 3 = Analytical and experimental critical function and/or characteristic proof of concept, Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative*) . At this point in time, the subsystems have been proven to be sound and operable, including the eyepiece optical system, the display electronics, the eye tracker, and the mechanical pivot system.

It is the goal of the Phase II program to advance the TRL to Level 4 during the final phase integration of a working system which can be delivered to the Navy. This system will integrate all the subassembly hardware and demonstrate the software coordination of video and eye tracking. (*TRL 4 = Component and/or breadboard validation in laboratory environment, Basic technological components are integrated to establish that the pieces will work together*).

One the Phase II program is completed, the next general step is to integrate the display system into an actual simulator environment, resulting in a rapid jump to TRL 6 or perhaps 7. At the same time, the form and fit of the hardware will be further optimized to promote ergonomic functions and interfaces with other military equipment (helmet types, gas masks, etc.) This system will allow the military to conduct user trials to validate the end-item performance and feasibility. Once the operational suitability is determined to be successful, the final step is to enter a limited production program.

## REFERENCES

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## ABOUT THE COMPANY

OASYS Technology, LLC is a Small Business in Manchester, New Hampshire which specialized in the design, development, and production of optical sensor and display equipment. OASYS specializes in optical and electro-optical design, and has a substantial in-house single-point diamond turning capacity for the fabrication of infra-red and plastic lenses. The OASYS product portfolio contains many military night vision sensors and displays, to include uncooled thermal weapon sights, fusion imagers, and a large scale production program for the Army's PEO Soldier which is delivering thousands of head-mounted displays for infantry use.