

## **Habitation 2004**

# **Utilization of the Space Vision System As An Augmented Reality System For Mission Operations**

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# Summary

Previous research has shown that augmented reality can be an effective improvement for video based robotic operations. A question arises, however, as to whether such technology can be implemented using existing flight hardware. To answer this question, the Canadian Space Vision System (SVS) was successfully tested as a 3D augmented reality system capable of improving human performance for operations requiring video monitor viewing. SVS is certified for flight, and it is currently flown for ISS assembly missions. Development of this system in ground-based experiments will demonstrate its potential for on-orbit augmented reality operations using the Space Station's robotic arm.

# Augmented Reality

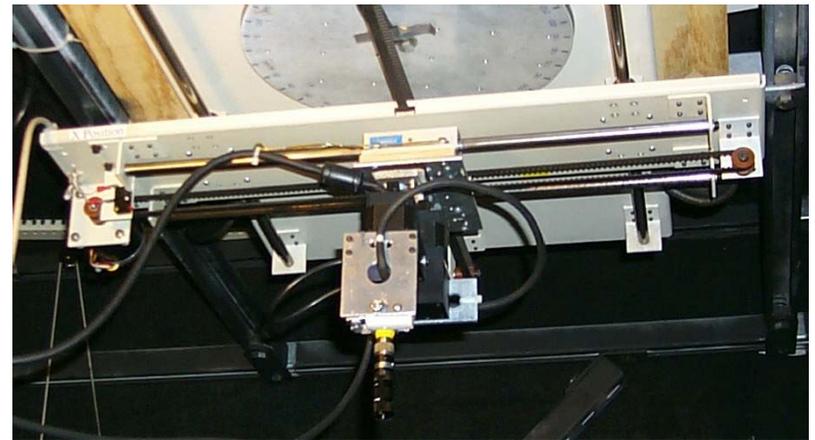
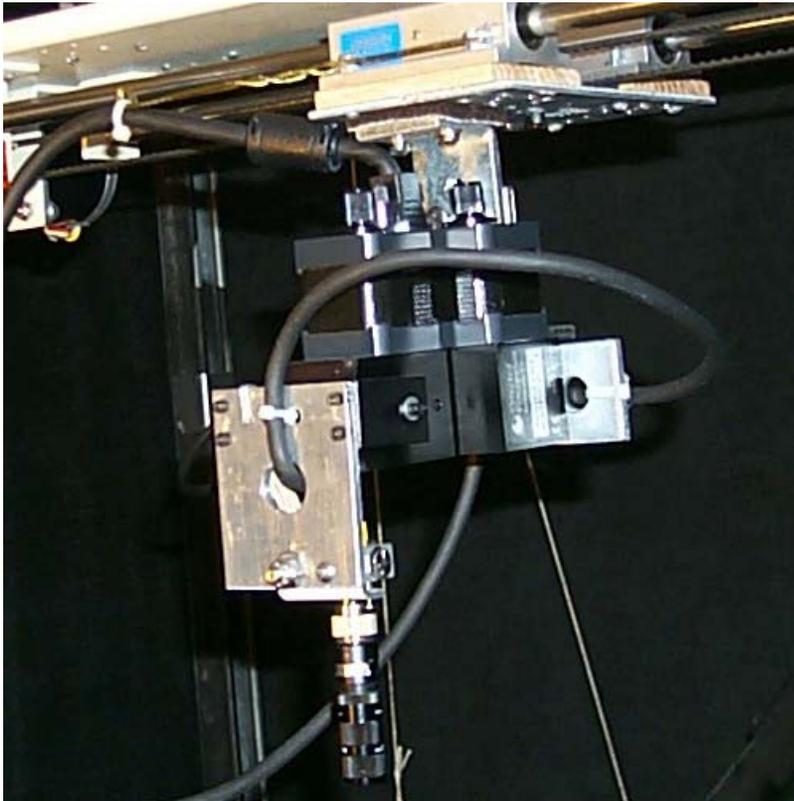
This technique is defined as the superposition of virtual computer graphics upon images of the real world.

Examples include Space Shuttle cockpit heads-up displays, 2D overlays for operational SVS displays, and alphanumeric displays for robotic operations.

# Target for the Experiment



# Video Camera Mounting



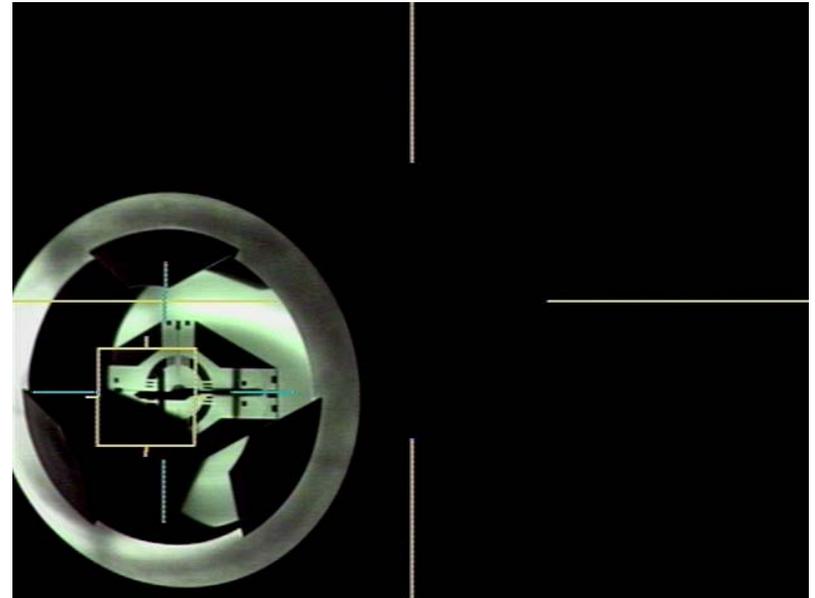
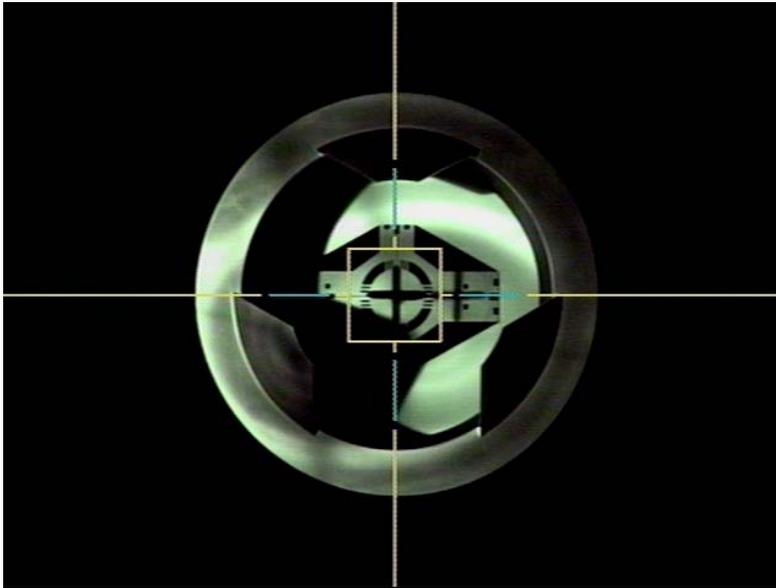
# Orbital Space Vision Unit Console



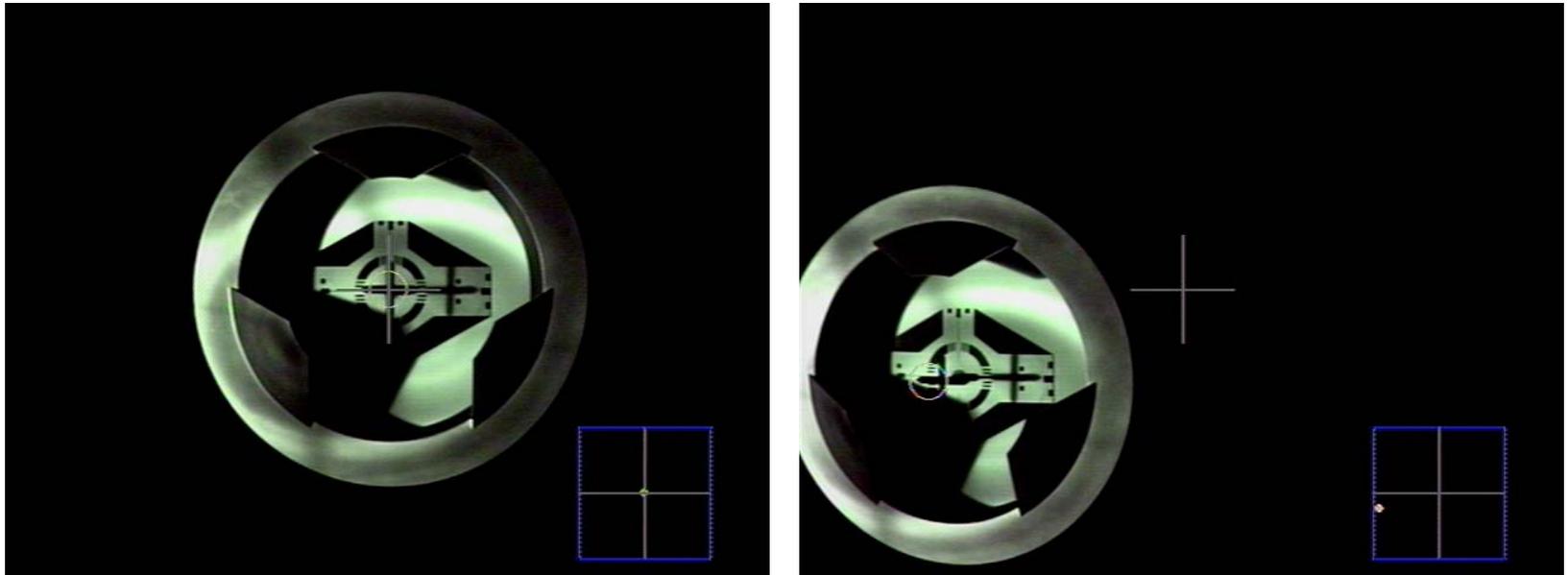
# Target without Overlay (None)



# Moving Box Overlay (Box)



# Position Grid Overlay (Grid)



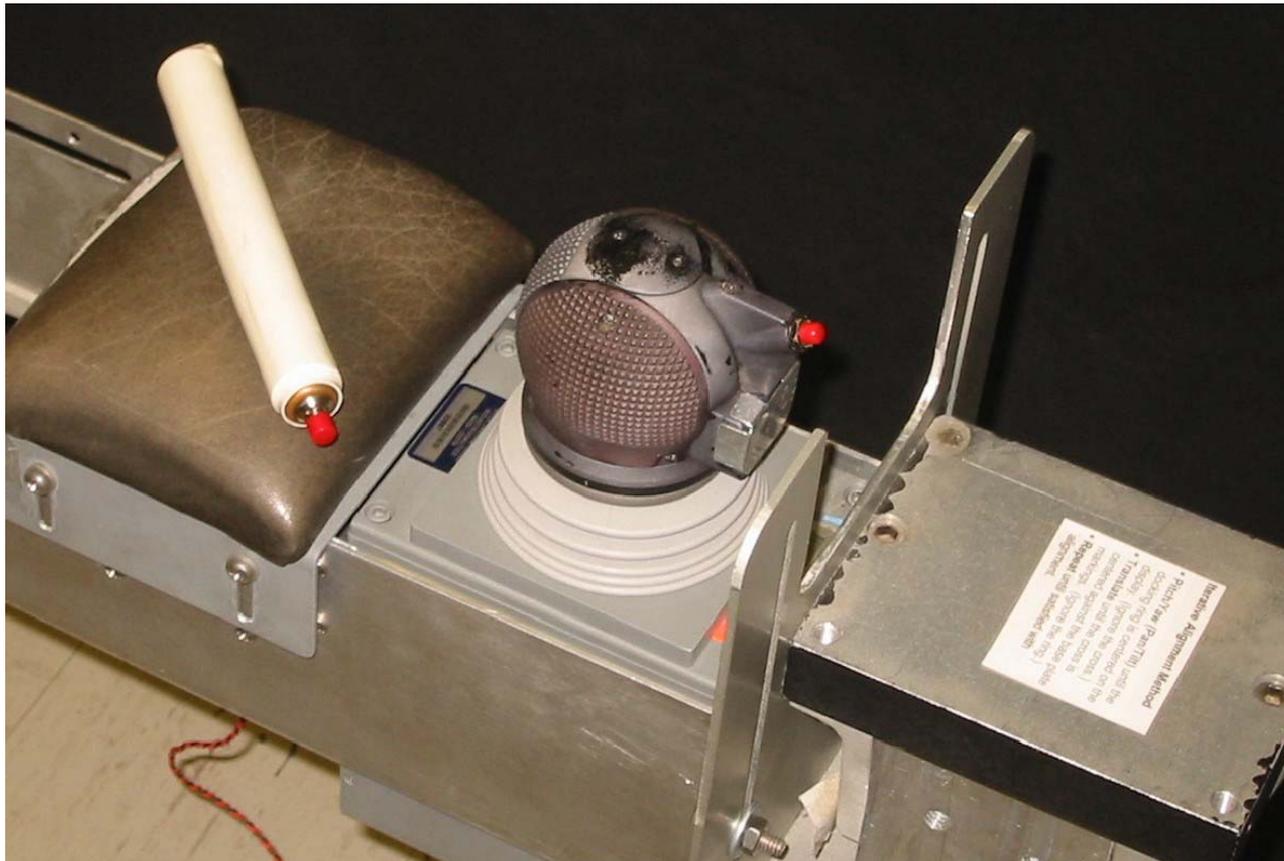
# Alphanumeric Overlay (Alpha)



# Features of the Experiment

- Subjects included 18 females and 18 males
- Repeated measures design with gender as the between subjects variable and overlay treatment as the within subjects variable
- 16 trials were in 4 groups of 4 trials each, having the same overlay treatment within a group
- Order of presentation of overlays was balanced
- Trial administration was automated and self-paced
- Trials were preceded by a familiarization session
- Novel hand controller was used to minimize effect of prior experience

# Hand Controller and Pendant Switch



# Data and Analysis

Data was recorded at 18 samples per second:

- Camera pivot point position
- Camera pan and tilt angles
- Hand controller translation commands
- Hand controller pan/tilt commands

All analysis was based on means for last 3 of 4 trials in each trial group.

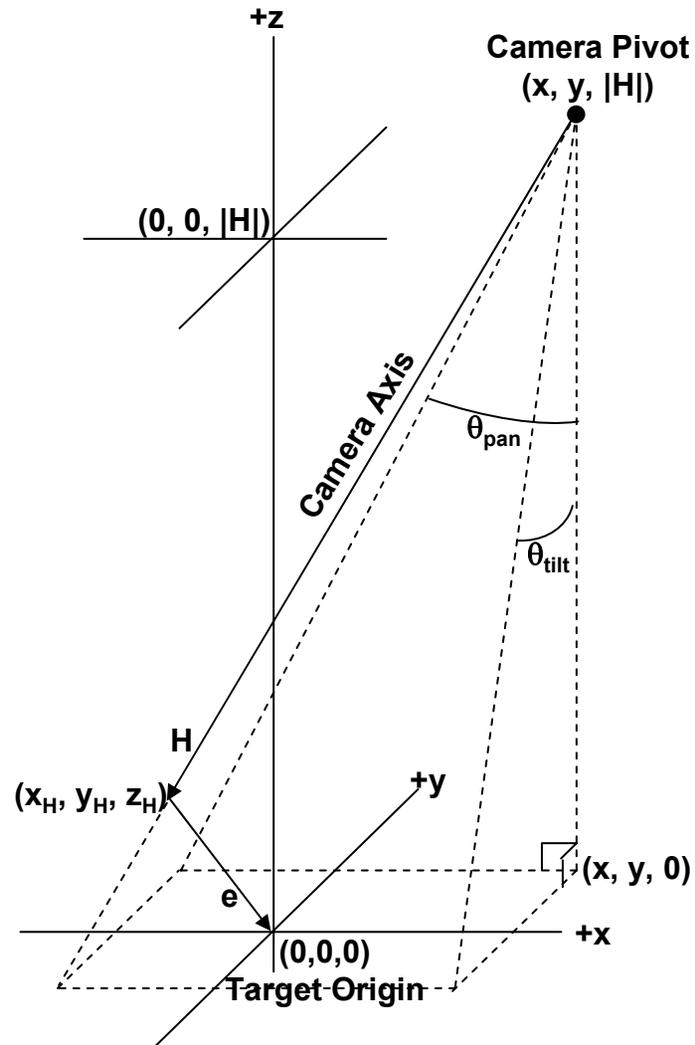
Metrics:

- Elapsed time for trial completion
- Composite camera alignment error calculations
- Hand controller error frequencies:

Reversal errors

Overshoot errors

# Composite Camera Alignment Error

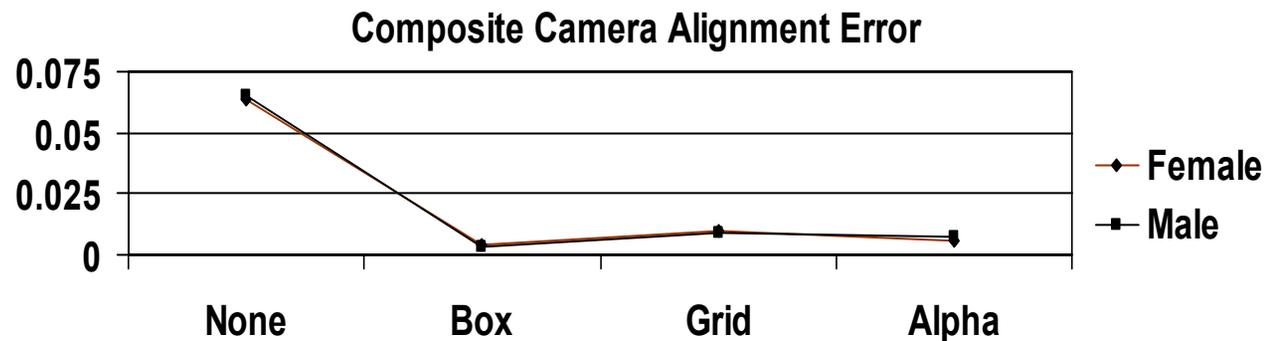


## Results – Composite Camera Alignment Error

There were statistically significant differences between composite alignment errors obtained with different overlays ( $p < 0.0001$ ):

- Smaller errors with overlays than with no overlay ( $p < 0.0001$ )
- Smaller errors with the Box Overlay than with the Grid or Alpha Overlays ( $p < 0.04$ )
- No statistical difference between errors with the Grid and Alpha Overlays ( $p > 0.05$ )

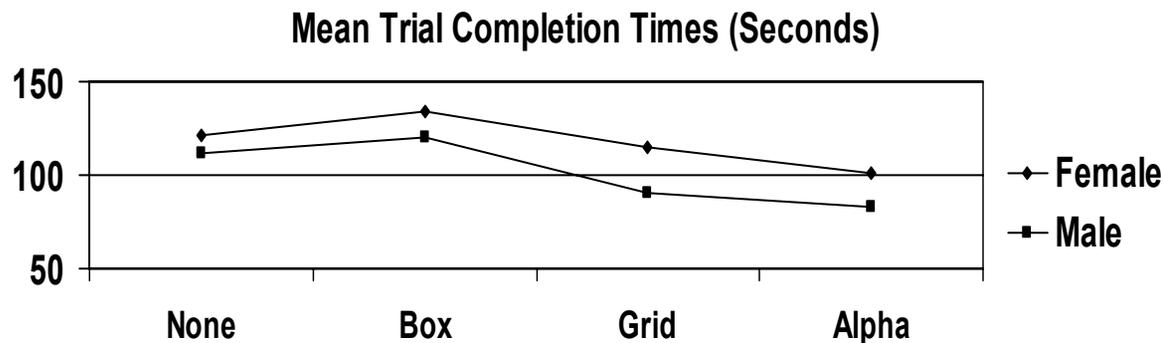
There were no gender-related differences in composite alignment error.



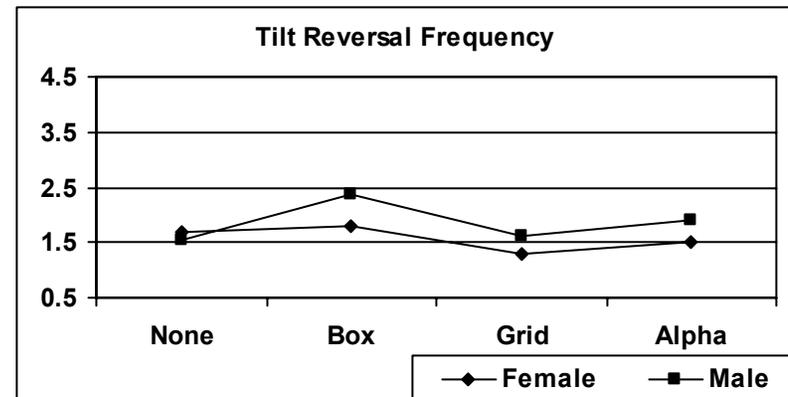
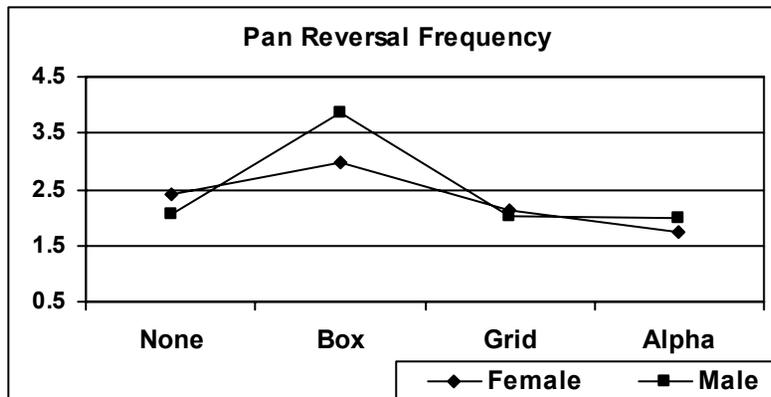
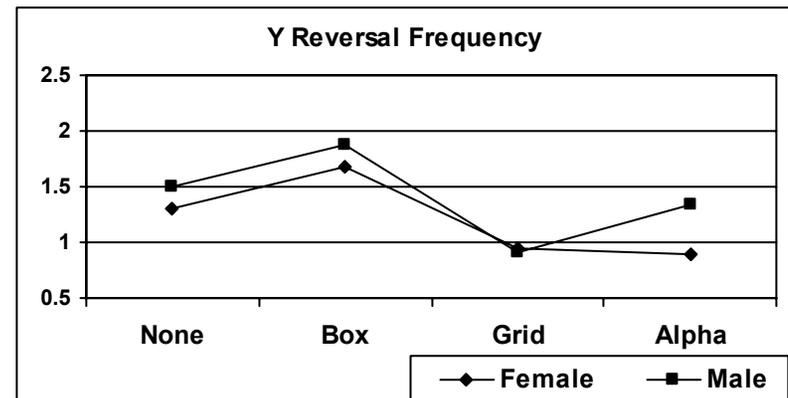
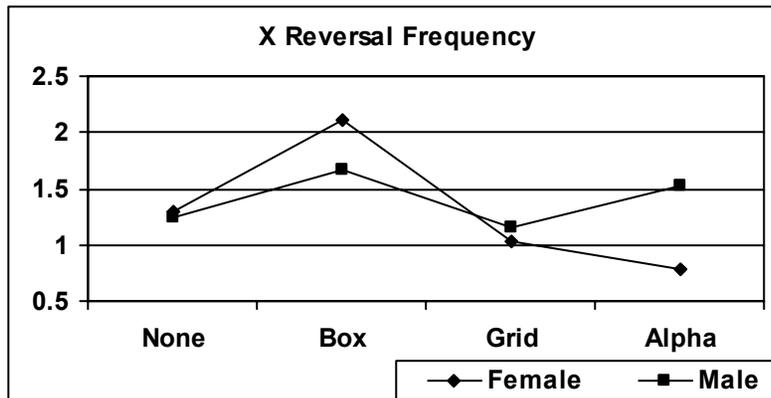
## Results – Elapsed Time to Trial Completion

There were statistically significant differences between completion times obtained with different overlays ( $p < 0.0001$ ) and attributed to gender:

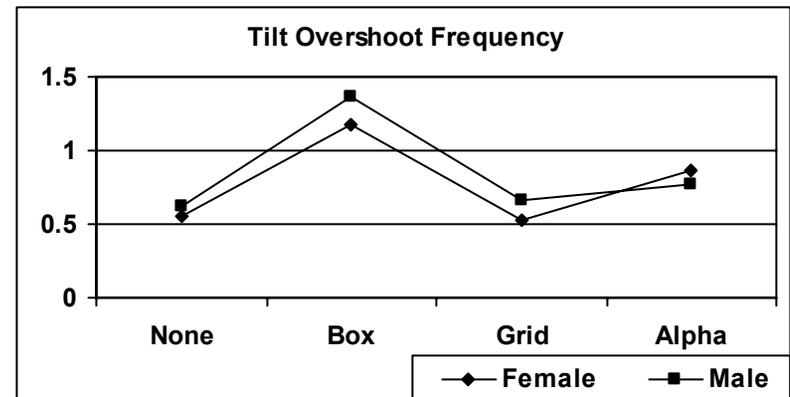
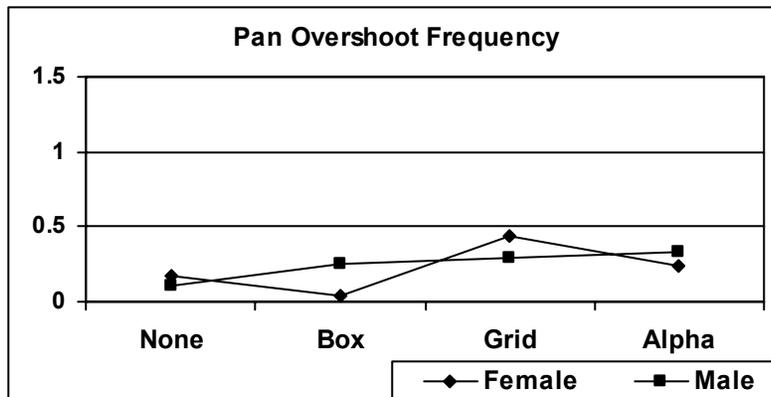
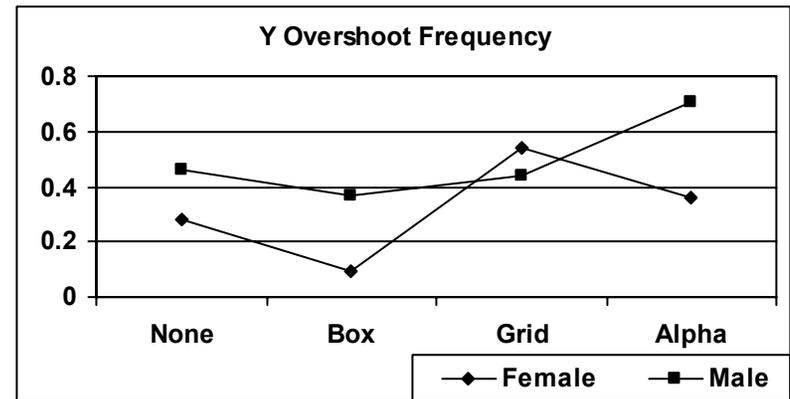
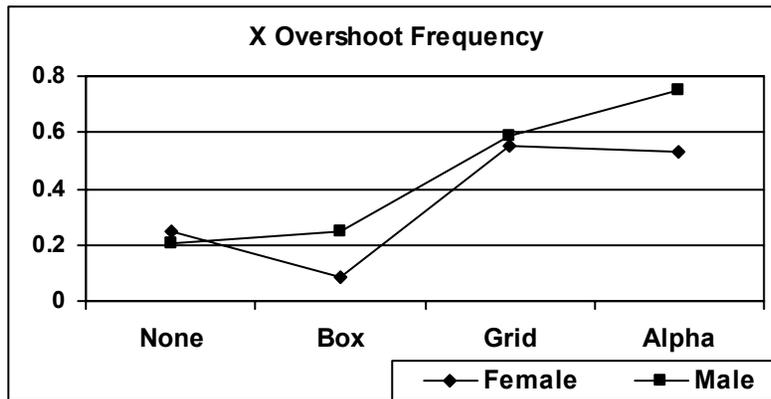
- No significant difference in completion times between the Grid and Alpha Overlays or between the Box Overlay and no overlay
- Completion times were significantly shorter for the Grid and Alpha Overlays than with the Box Overlay or no overlay
- Females required more time to complete the trials ( $p < 0.02$ )



# Hand Controller Reversal Errors



# Hand Controller Overshoot Errors



## Discussion

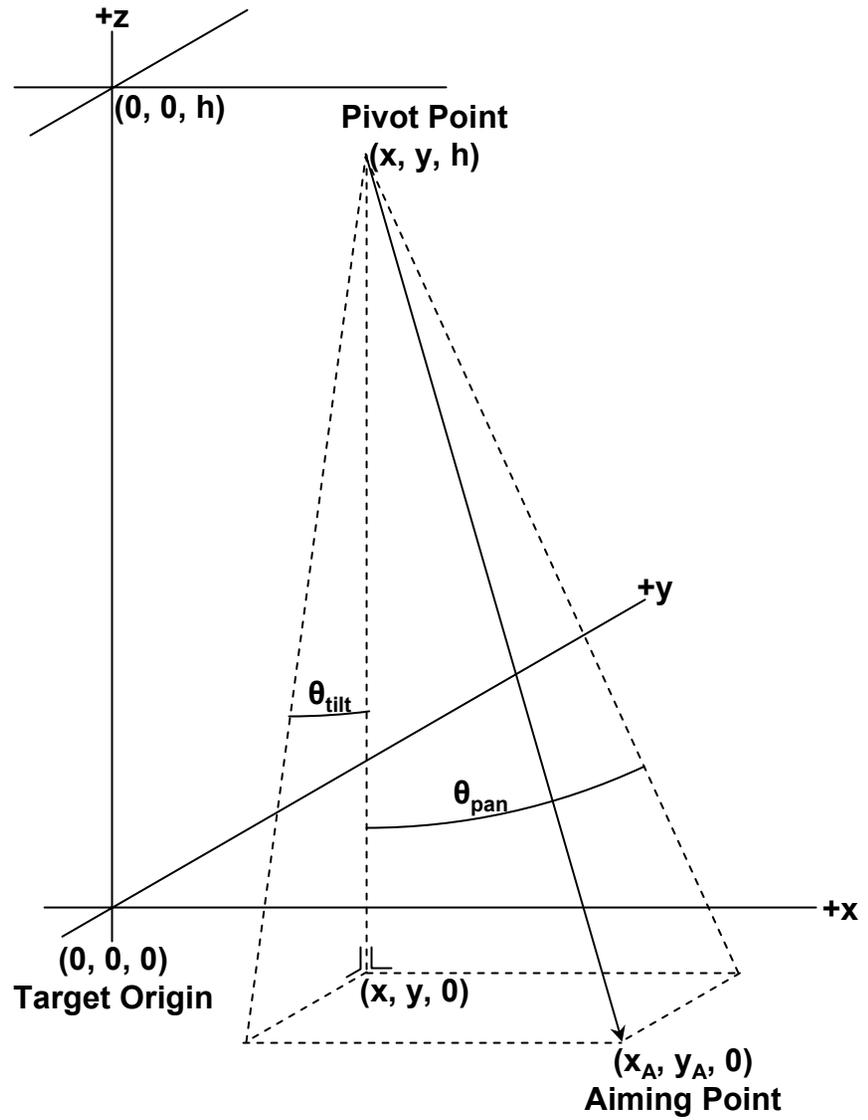
- SVS has been shown to be a capable 3D augmented reality platform with potential applications in robotic training and as an additional resource for an ongoing NRA project and possible on-orbit robotic experiments.
- Appropriate augmented reality overlays have been shown to offer significant improvements in robotic control performance.
- Hand controller reversal and overshoot error frequencies have been introduced as metrics that may prove useful in robotic training and task evaluation.

# Acknowledgement

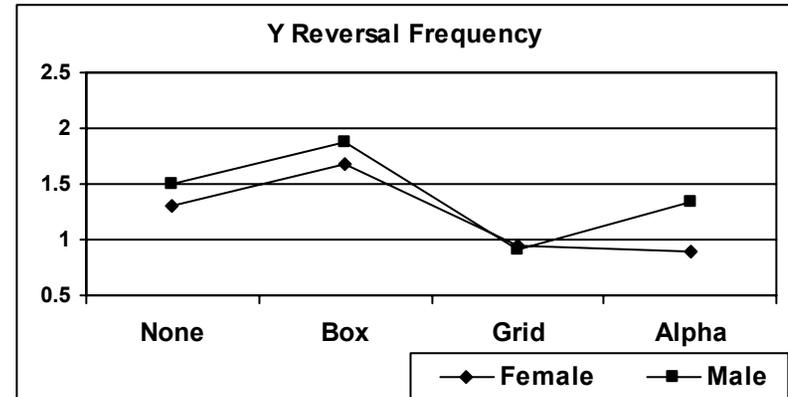
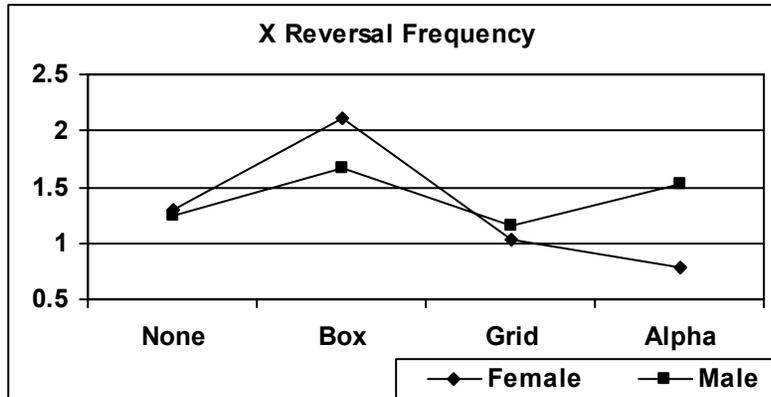
Thanks to Neptec International for providing timely hardware and software support for the project.

# Hand Controller Error Detailed Results

# Geometry for Hand Controller Error Determination



# Results – Hand Controller Translation Reversal Frequency



X Reversals (Gender x Overlay interaction present):

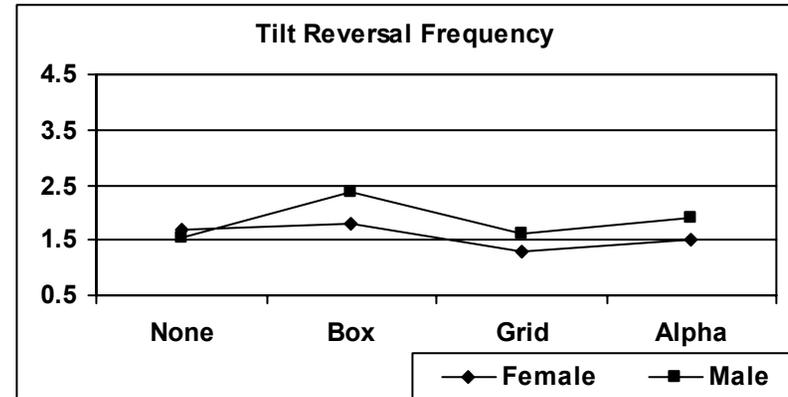
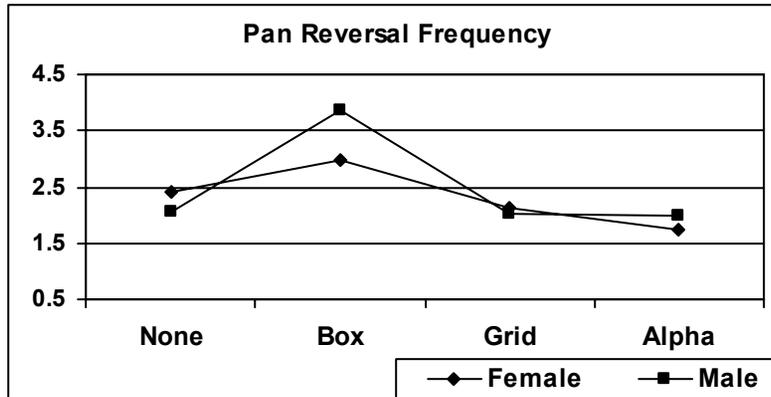
Females exhibited significantly higher reversal frequencies with the Box Overlay than with either the Grid or Alpha Overlays.

Males exhibited no significant differences in frequencies among overlays.

Y Reversals:

Subjects exhibited significantly higher reversal frequencies with the Box Overlay than with either the Grid or Alpha Overlay.

## Results – Hand Controller Pan/Tilt Reversal Frequency



Pan Reversals (Gender x Overlay interaction present):

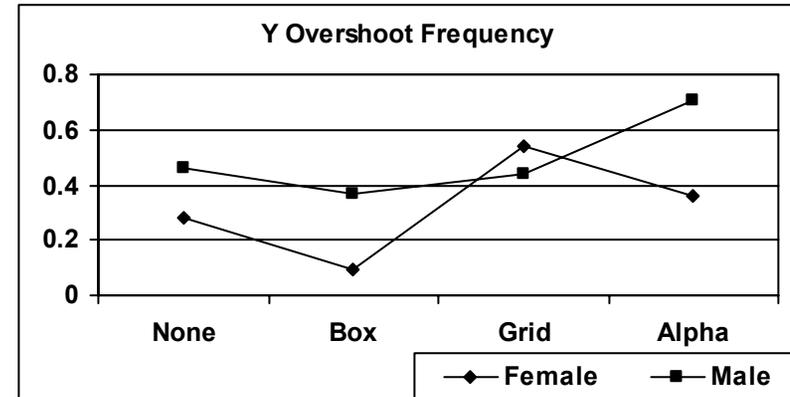
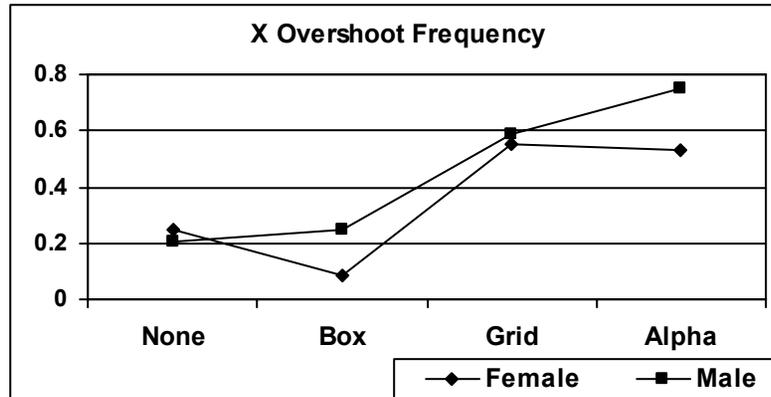
Males exhibited significantly higher reversal frequencies with the Box Overlay than with the Grid Overlay, the Alpha Overlay, or no overlay.

Females exhibited no significant differences in frequencies among overlays.

Tilt Reversals:

Subjects exhibited no significant differences in reversal frequencies among the different overlay treatments.

# Results – Hand Controller Translation Overshoot Frequency



## X Overshoot Frequency:

Subjects exhibited significantly higher X overshoot frequencies with the Grid Overlay and with the Alpha Overlay than with no overlay or the Box Overlay.

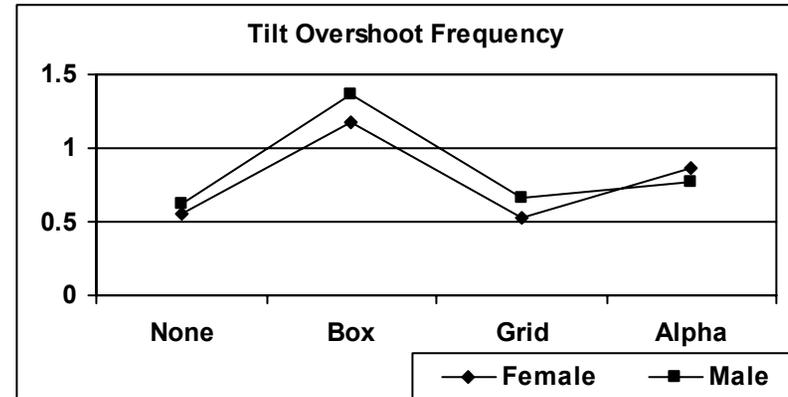
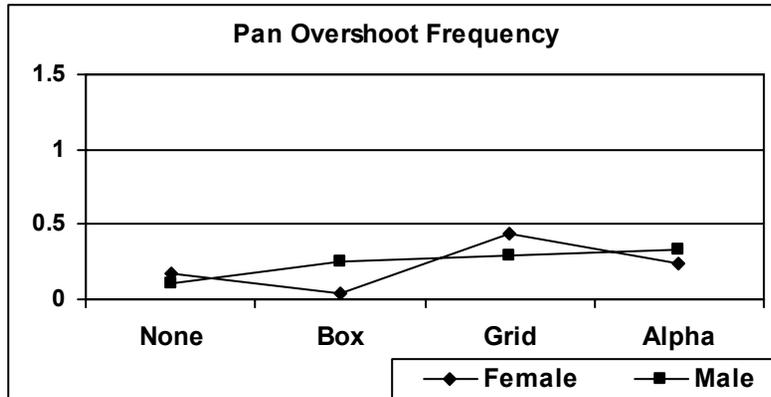
## Y Overshoot Frequency (Gender x Overlay interaction present):

Females exhibited significantly higher Y overshoot frequencies with the Grid Overlay than with no overlay and higher frequencies with no overlay than with the Box Overlay.

Females exhibited significantly higher Y overshoot frequencies with the Grid Overlay than with no overlay.

Males exhibited no significant differences in Y overshoot frequencies when using different overlays.

# Results – Hand Controller Pan/Tilt Overshoot Frequency



Pan Overshoot Frequency (Gender x Overlay interaction present):

Females exhibited significantly more pan overshoots with the Grid Overlay than with the Alpha Overlay and more pan overshoots with the Alpha Overlay than with no overlay.

Females exhibited significantly more pan overshoots with the Grid Overlay than with no overlay.

Males exhibited no significant differences in pan overshoot frequencies when using different overlays.

Tilt Overshoot Frequency:

Subjects exhibited significantly more tilt overshoots with the Box Overlay or Alpha Overlay than with no overlay.

Subjects exhibited significantly more tilt overshoots with the Box Overlay than with the Alpha Overlay and more tilt overshoots with the Alpha Overlay than with the Grid Overlay.