NASA Papilledema Summit

July 27-28, 2009

Background: preflight screening, in-flight capabilities, & postflight testing

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Astronaut Selection

- Since 1959, more than 300 men and women have been selected for service in the U.S. Space Program as pilots, mission specialists, or payload specialists.
- In the early years of the U.S. Space Program, all astronauts were military test pilots and thus were required to meet the rigorous vision standards of the military.
- Because vision is critical for astronaut function and survival, the eyes of astronaut candidates are thoroughly evaluated with standard and specialized equipment.

Current Astronaut Selection Vision Exam:

- Uncorrected Visual Acuity
- Manifest Refraction
- Cycloplegic Refraction
- Color Vision (PIP)
- Stereopsis (OPTEC, Randot)
- NPA (Accommodation)
- NPC (Convergence)
- Red Lens Test
- Pupils
- Heterophoria (Cover Test)
- IOP (Applanation)
- Biomicroscopy
- Ophthalmoscopy
- Retinal Photography
- Visual Fields (Humphrey 30-2)
- Corneal Topography

Pilot - Eye Standards

	Jan 1977	Dec 1983	Oct 1988	Jun 1991	Aug 1995	Feb 1997	Jul 1998	Mar 1999	Mar 2009
DVA	20/50	20/50	20/50	20/50	20/50	20/70	20/70	20/100	NA
Refract-ion	+1.75 –1.00	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+3.50 -4.50
Astig-matism	1.25 NA	3.00 DQ	3.00 DQ	3.00 DQ	3.00 DQ	3.00 DQ	3.00 DQ	3.00 DQ	2.00
Depth Percep.	Y	Y	Y	Y	Y	Y	Y	Y*	Y*
Color Vision	Y	Y	Y	Y	Y	Y	Y	Y**	Y**
Ortho-K	NA	DQ	DQ 2YR	DQ 2YR	DQ 6MO	DQ 6MO	DQ 6MO	DQ 6MO	DQ 6MO
Refract Surgery	NA	DQ	DQ	DQ	DQ	DQ	DQ	DQ	A***

*Stereopsis testing changed from Verhoeff to Optec 2300

**Color Vision testing changed to Dvorine PIP with FALANT as secondary test

***LASIK and PRK approved for selection and retention

Mission Specialist - Eye Standards

	Jan 1977	Dec 1983	Oct 1988	Jun 1991	Aug 1995	Feb 1997	Jul 1998	Mar 1999	Mar 2009
DVA	20/50	20/100	20/100	20/150	20/200	20/200	20/200	20/200	NA
Refract-ion	+2.50 –2.00	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+/-5.50	+/-5.50
Astig-matism	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Depth Percep.	Y	Y	Y	Y	Y	Y	Y	Y*	Y*
Color Vision	Y	Y	Y	Y	Y	Y	Y	Y**	Y**
Ortho-K	NA	DQ	DQ 2YR	DQ 2YR	DQ 6MO	DQ 6MO	DQ 6MO	DQ 6MO	DQ 6MO
Refract Surgery	NA	DQ	DQ	DQ	DQ	DQ	DQ	DQ	A***

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NASA Vision Standards (Astronaut Selection)

Retina and Vitreous

- History or presence of retinal detachment, unless traumatic with no sequelae, retinal tears, or edema.
- Retinal hole with presence of fluid or vitreous traction. Other retinal holes require ophthalmic evaluation.
- Degeneration or dystrophies of the central or peripheral retina, including lattice degeneration, require ophthalmic evaluation.
- Pigmentary degeneration requires ophthalmic evaluation.
- Retinitis, chorioretinitis, or other inflammatory conditions of the retina, unless single episode that has healed and does not impair central or peripheral vision.
- Hemorrhages, exudates, or other retinal vascular conditions that potentially impair vision require ophthalmic evaluation.
- Vitreous opacities or conditions that may cause loss of central acuity or peripheral visual field require ophthalmic evaluation.

NASA Vision Standards

Optic Nerve

- **Presence or history of optic neuritis**
- Optic atrophy, primary or secondary.
- History of papilledema, pseudopapilledema, or papillitis requires ophthalmic evaluation.
- Congenito-hereditary conditions, including optic nerve drusen, that may interfere with central visual acuity or visual field.

NASA Vision Standards

Intraocular Pressure

- Glaucoma, identified by pressure greater than 30 mmHg in either eye, characteristic glaucomatous change in the optic nerve or visual field loss characteristic of glaucoma.
- Preglaucoma, identified by pressure on two determinations equal to or greater than 25 mmHg or a difference greater than 4 mmHg between eyes.
- Pigmentary Dispersion Syndrome requires ophthalmic evaluation.

Astronaut Demographics

Active NASA Astronauts	Pilot	MS	All
N	28	65	93
Mean Age	47	48	48

- 74 males, 19 females
- 9 recently selected astronaut candidates
- 29 ISS Expedition crew members (long duration)
- Between 1989 and 2009, there have been 478 STS (shuttle) crew members (short duration)

Astronaut Demographics

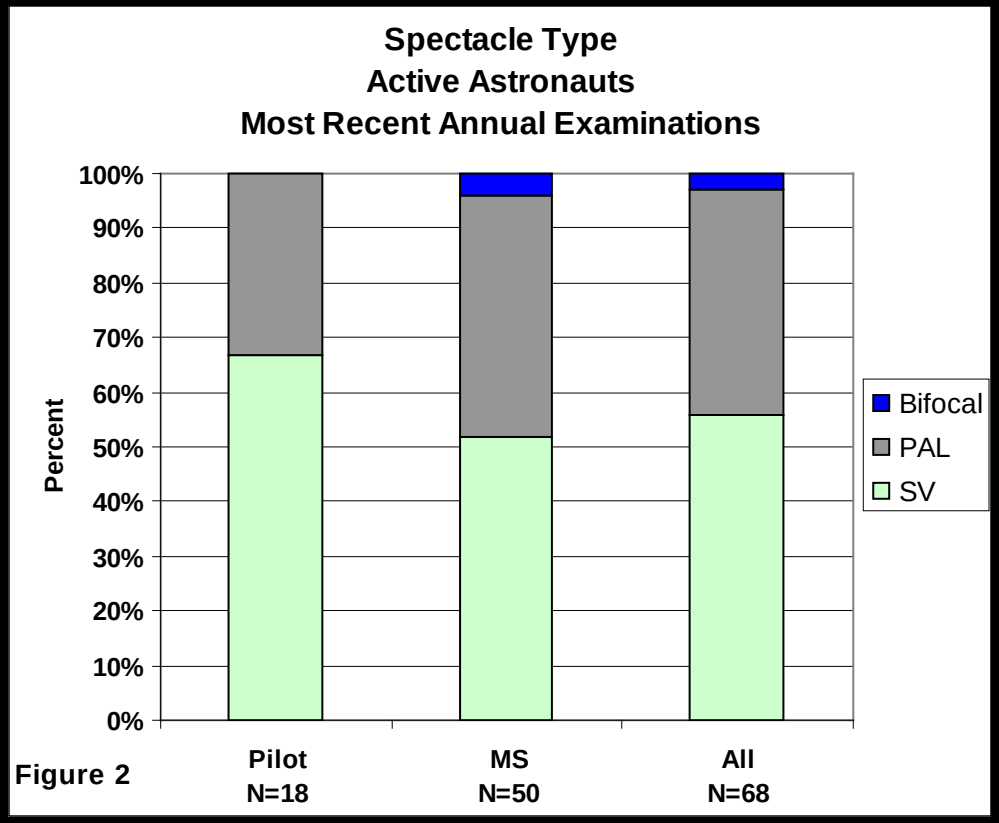


Figure 2

The percentage of spectacle types among active astronauts with a spectacle prescription, categorized as bifocal lens, progressive addition lens (PAL), or single vision lenses (SV). The astronauts are categorized as pilots and mission specialists (MS).

General Vision Issues of Space Flight

- Majority of Astronauts are Presbyopic
- 79% Wear Vision Correction (32% of which wear contact lenses)
- ~90% Wear Correction In Space
- 41% Wear Multifocal Prescriptions
- Hypercritical Observers!!!
- Critical Tasking / No Margin for Error
- Many Wear Varied Types of Correction based on tasks (NBL, Simulator, T-38, Space)

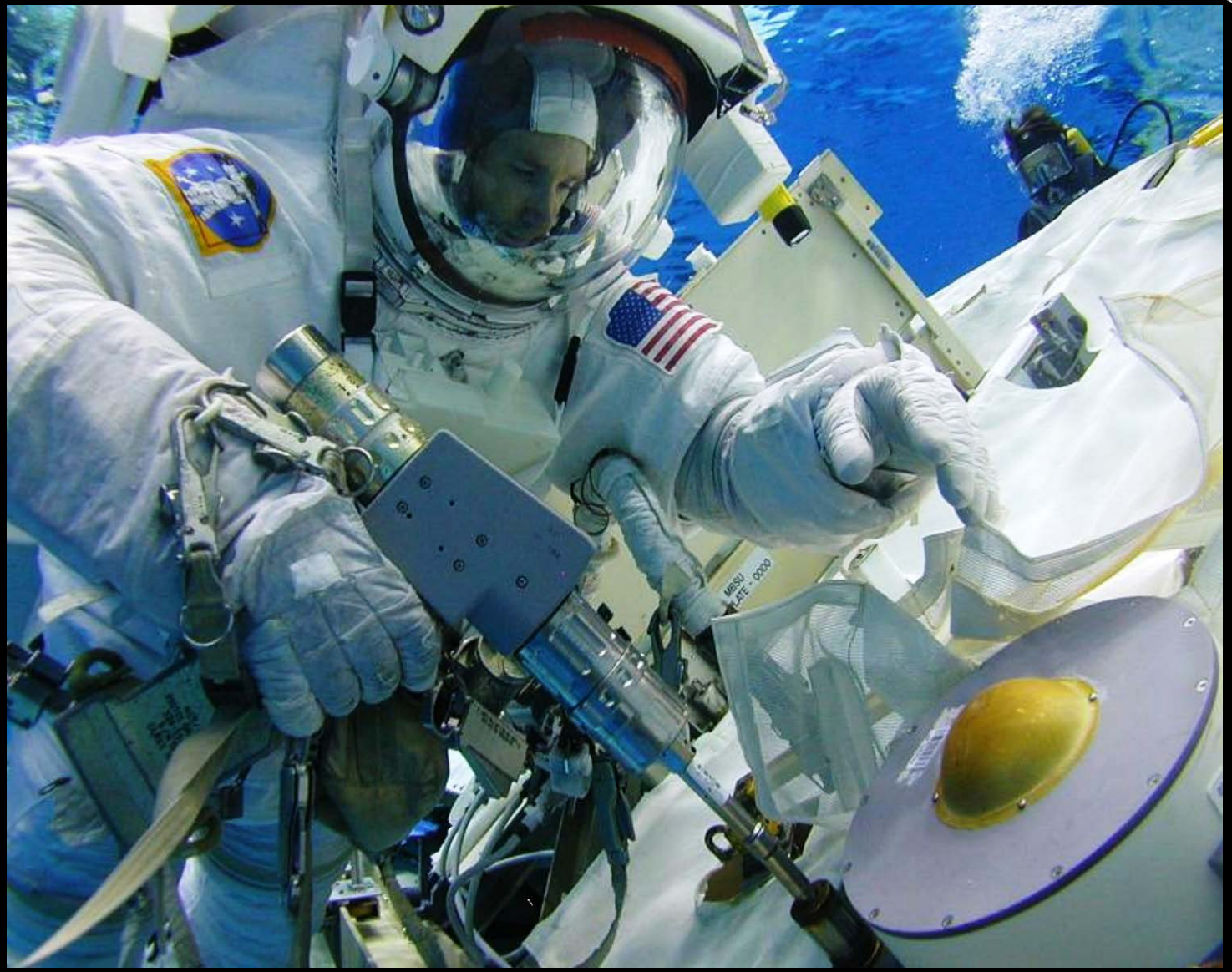
Simulator

Russian Soyuz Spacecraft

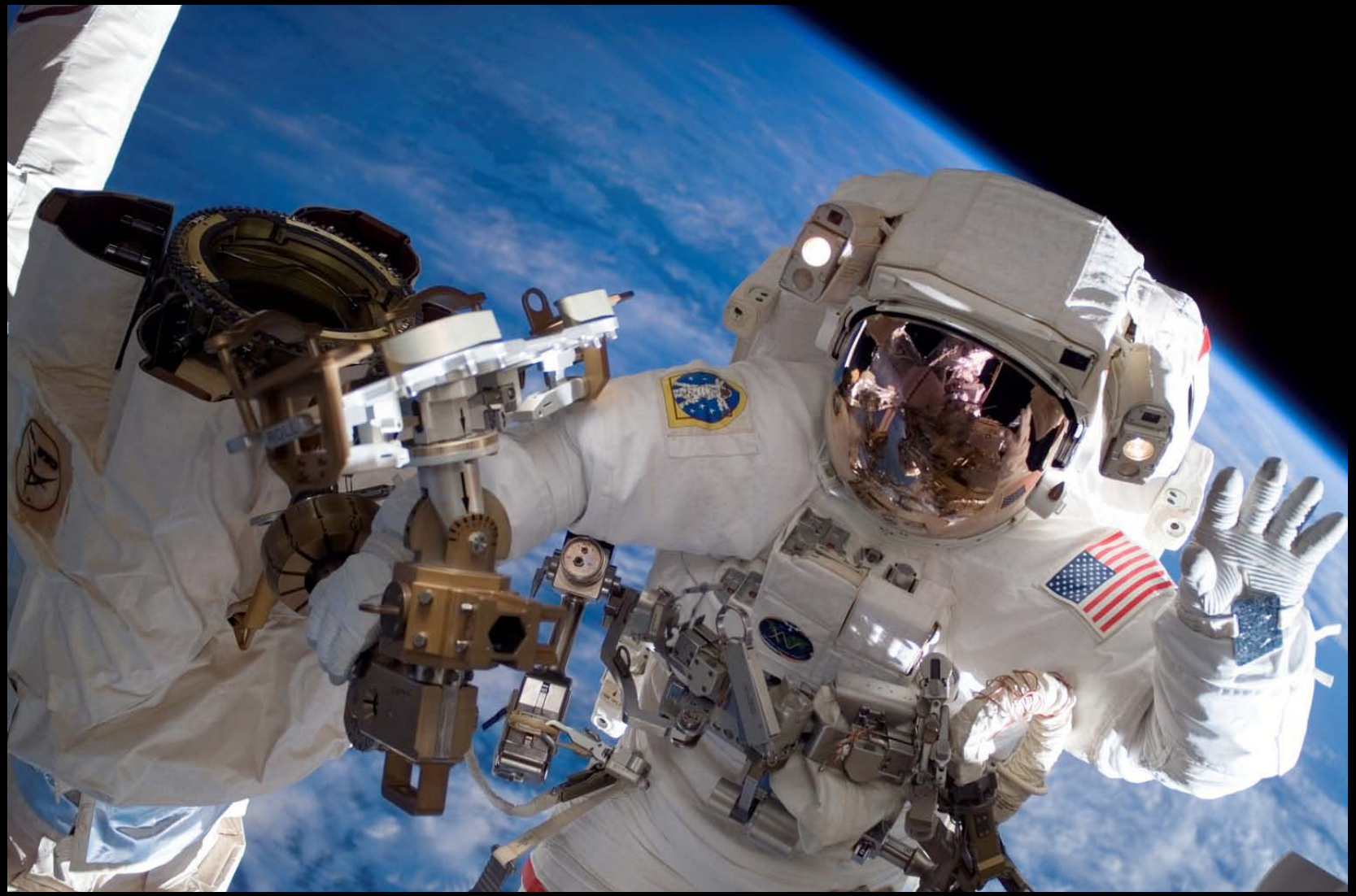
T-38

T-38 Cockpit

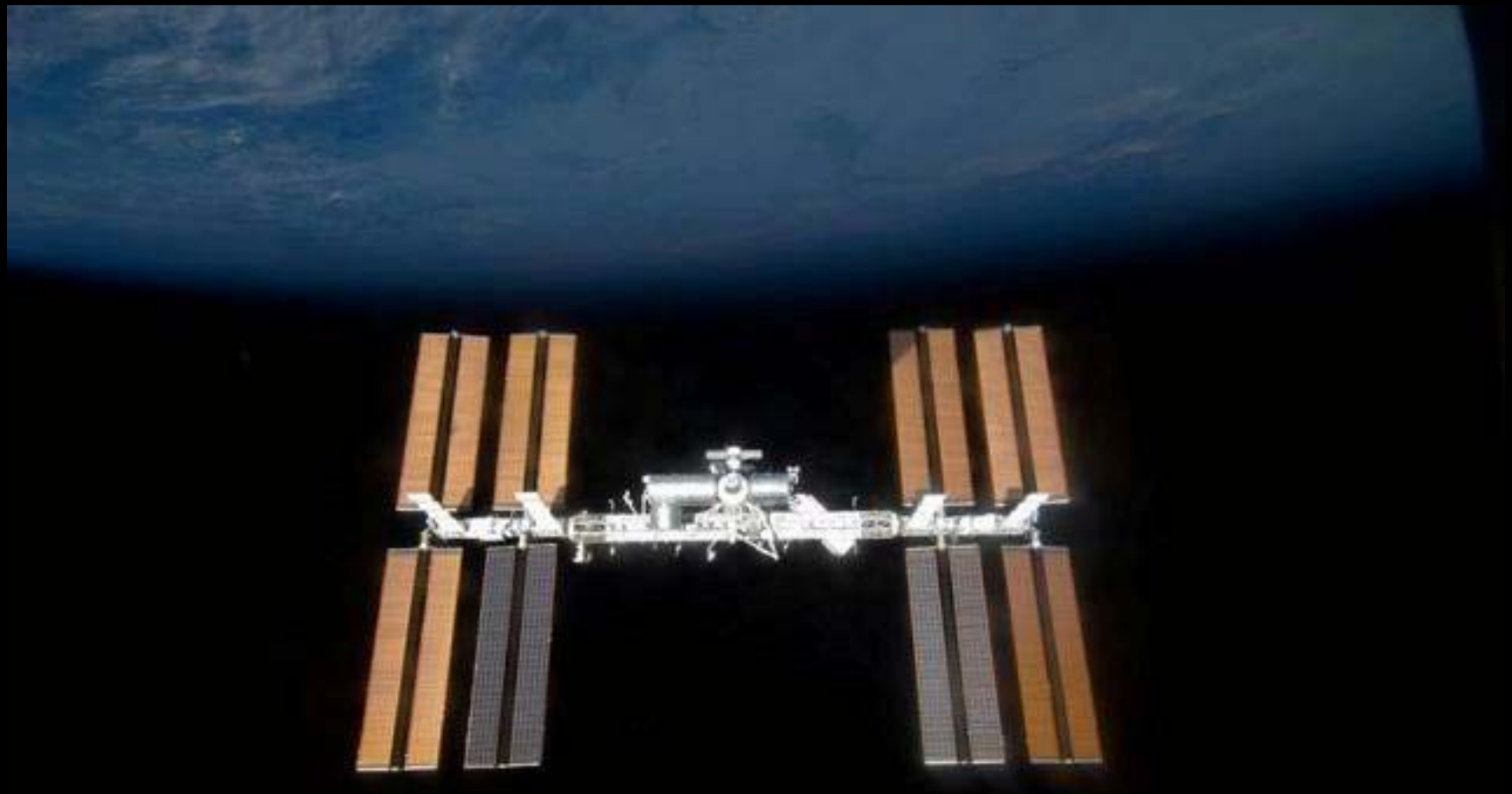
Neutral Buoyancy Lab (NBL)



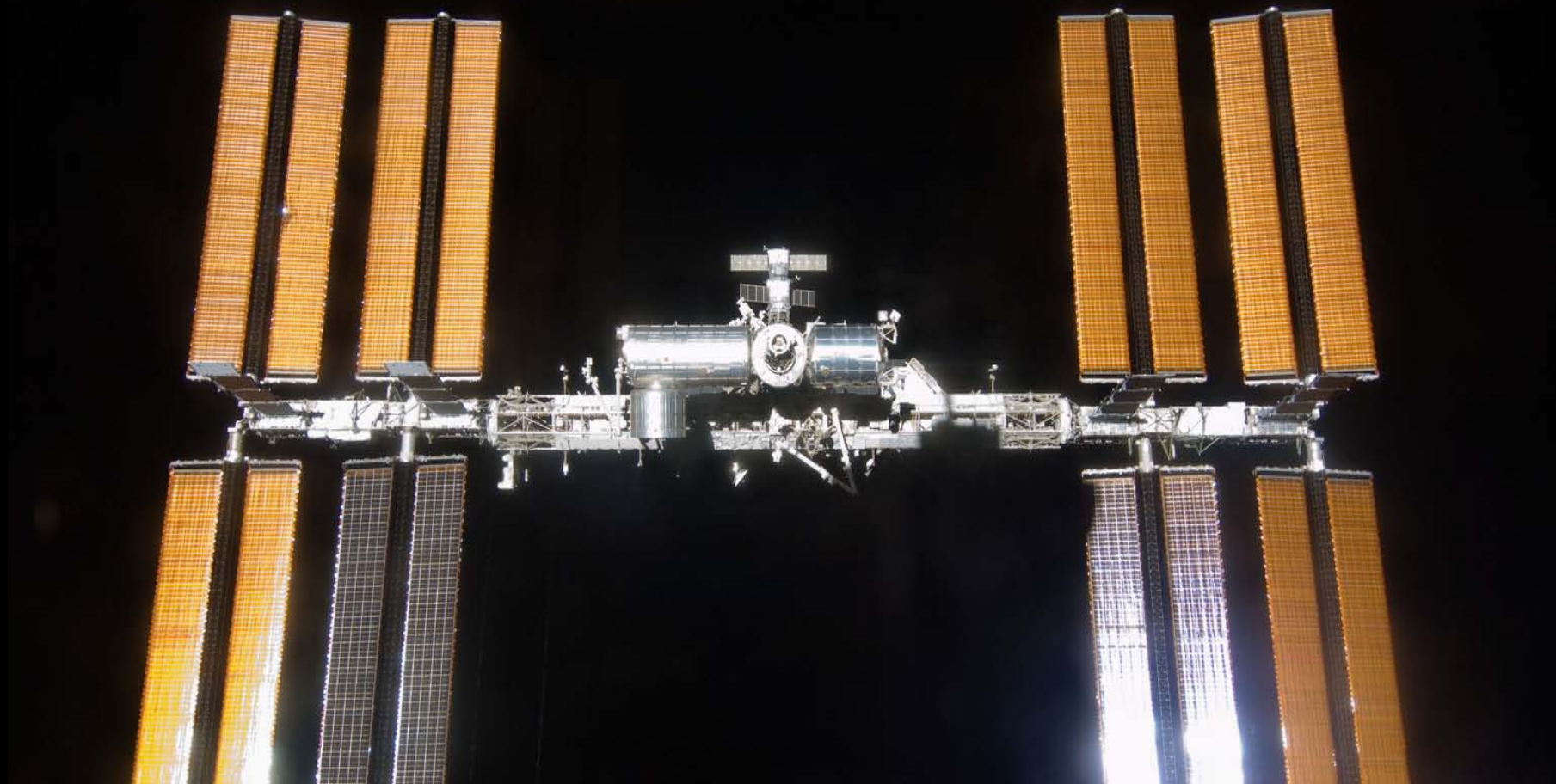
Extravehicular Activity (EVA)



International Space Station (ISS)



ISS

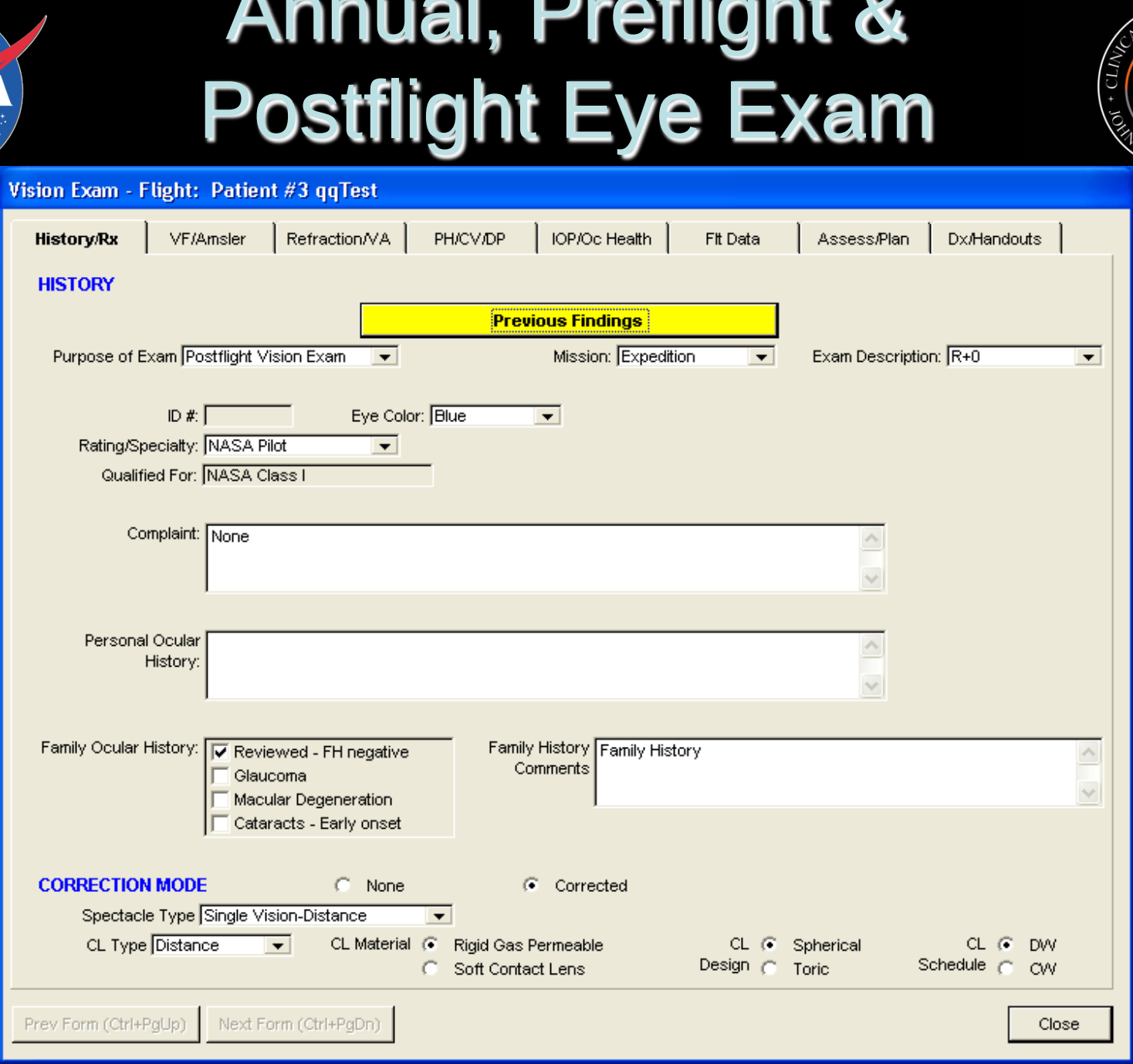


International Space Station

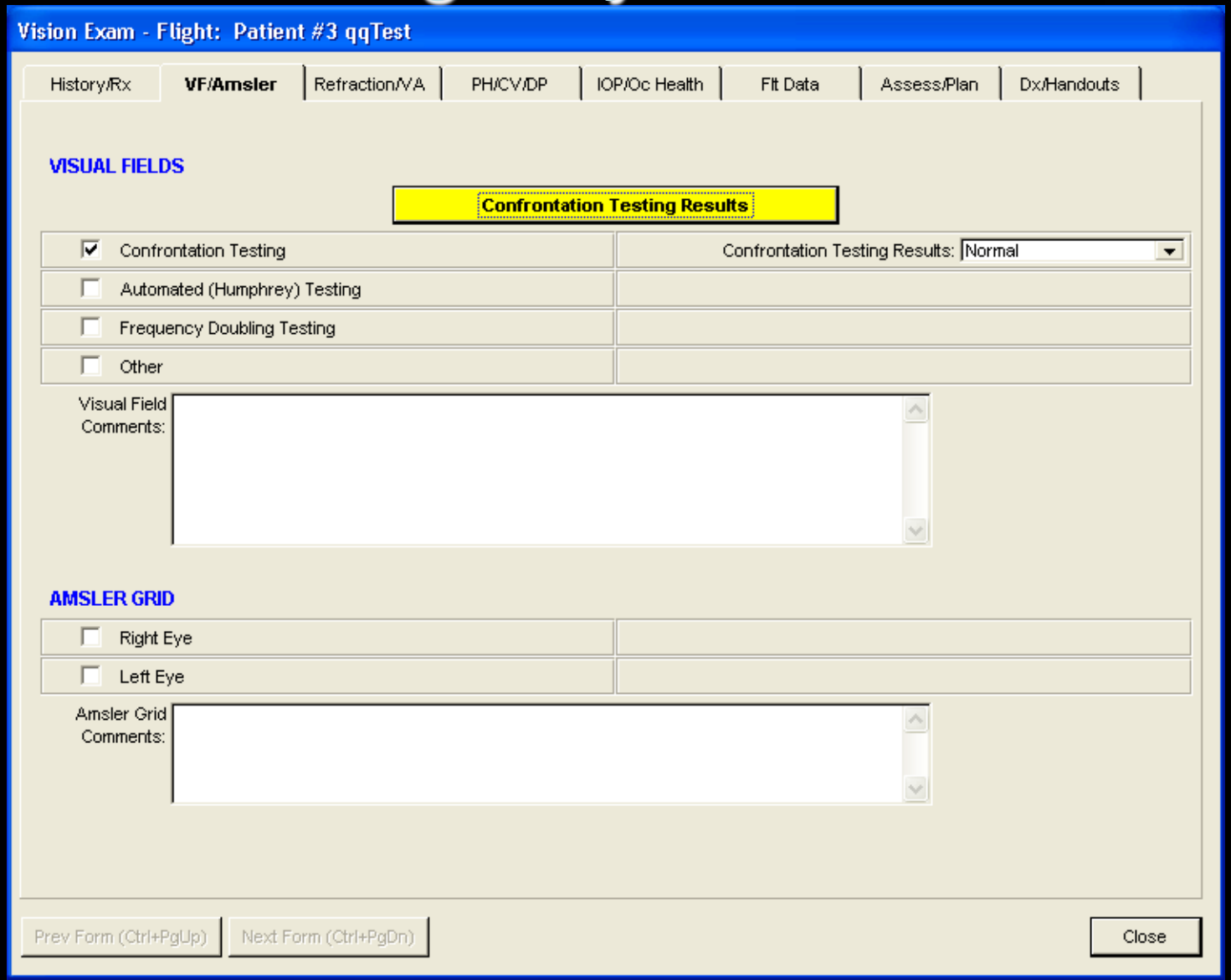
ISS017E012258

View from ISS window

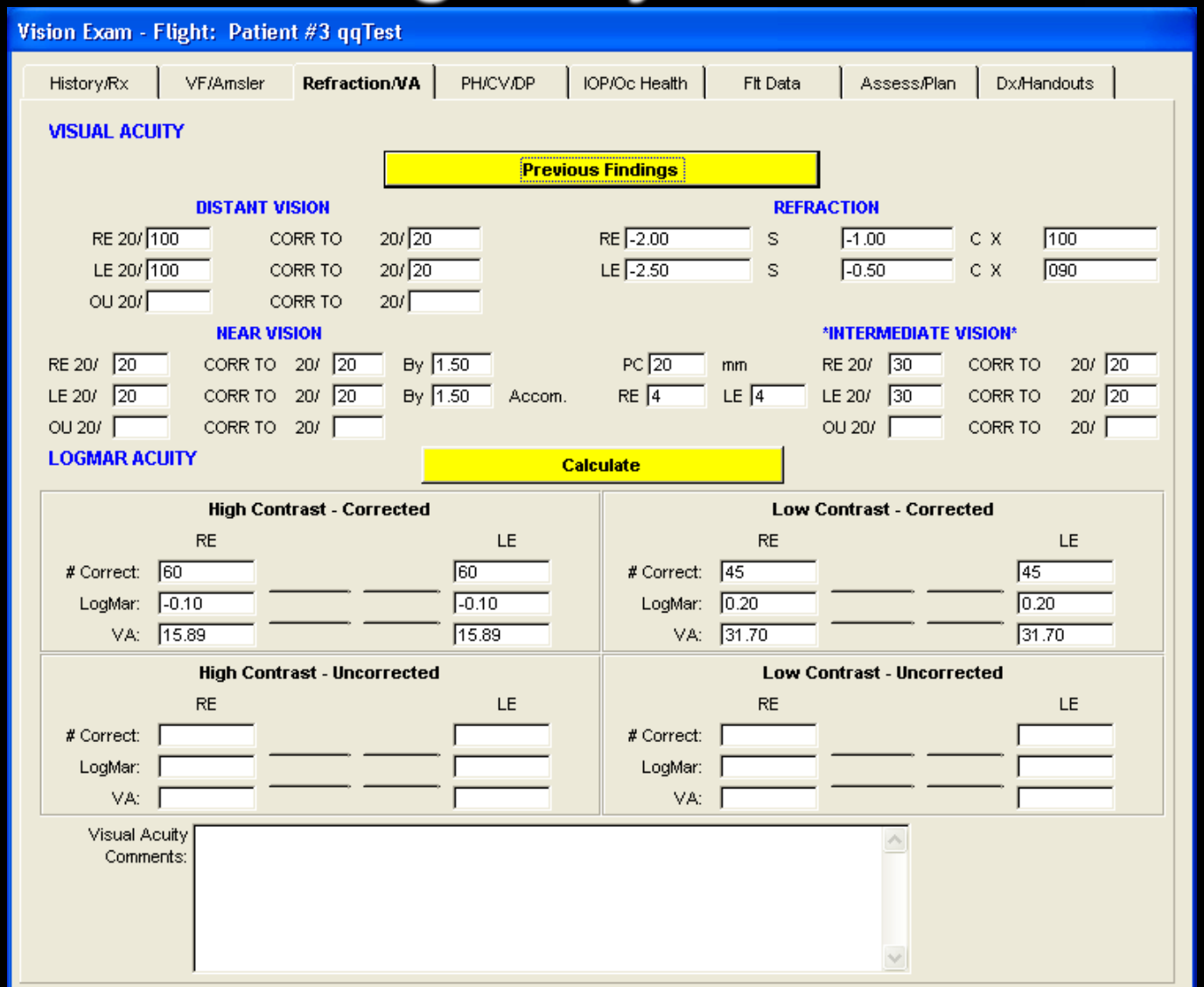
Annual, Preflight & Postflight Eye Exam



Annual, Preflight & Postflight Eye Exam



Annual, Preflight & Postflight Eye Exam



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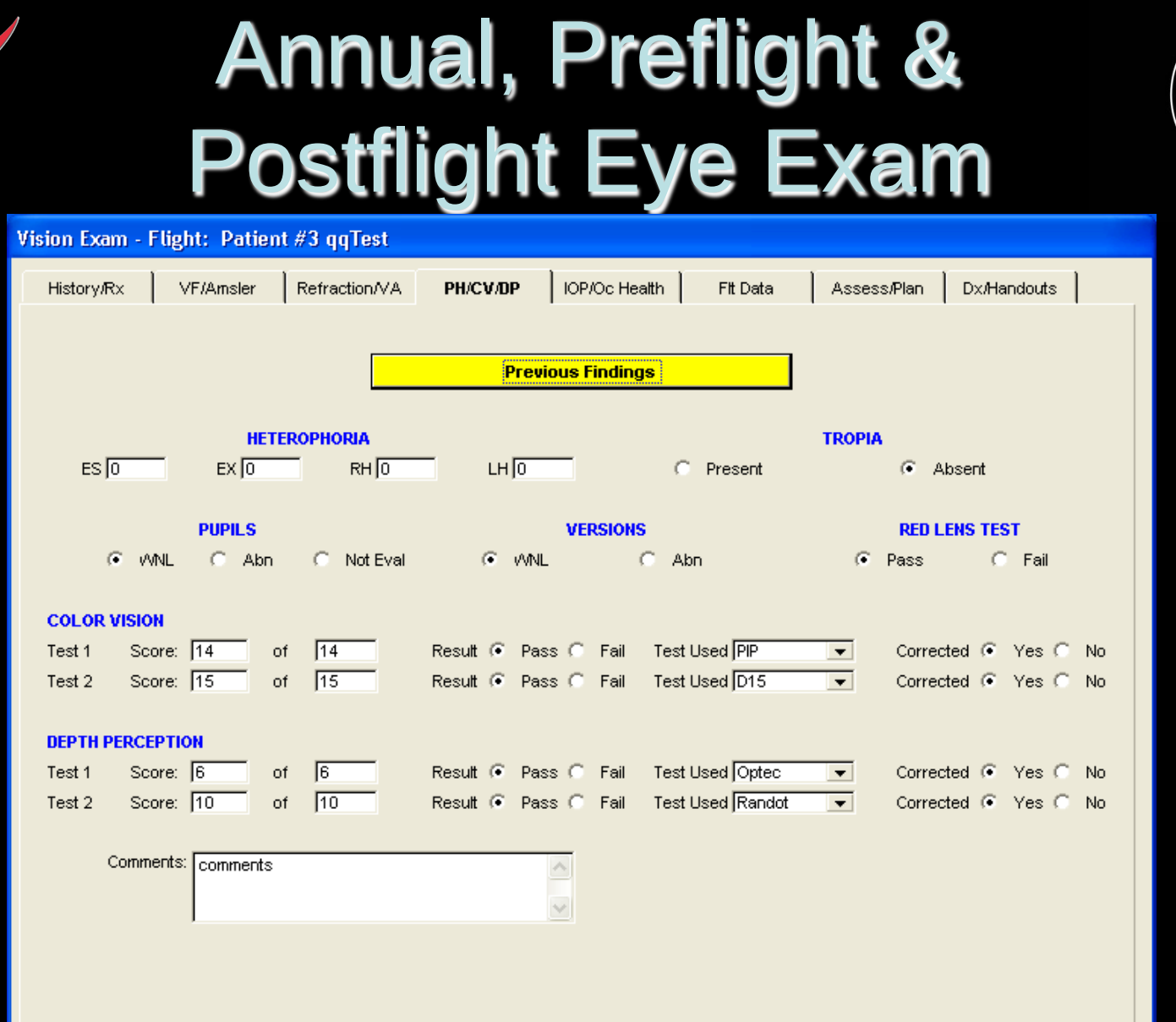

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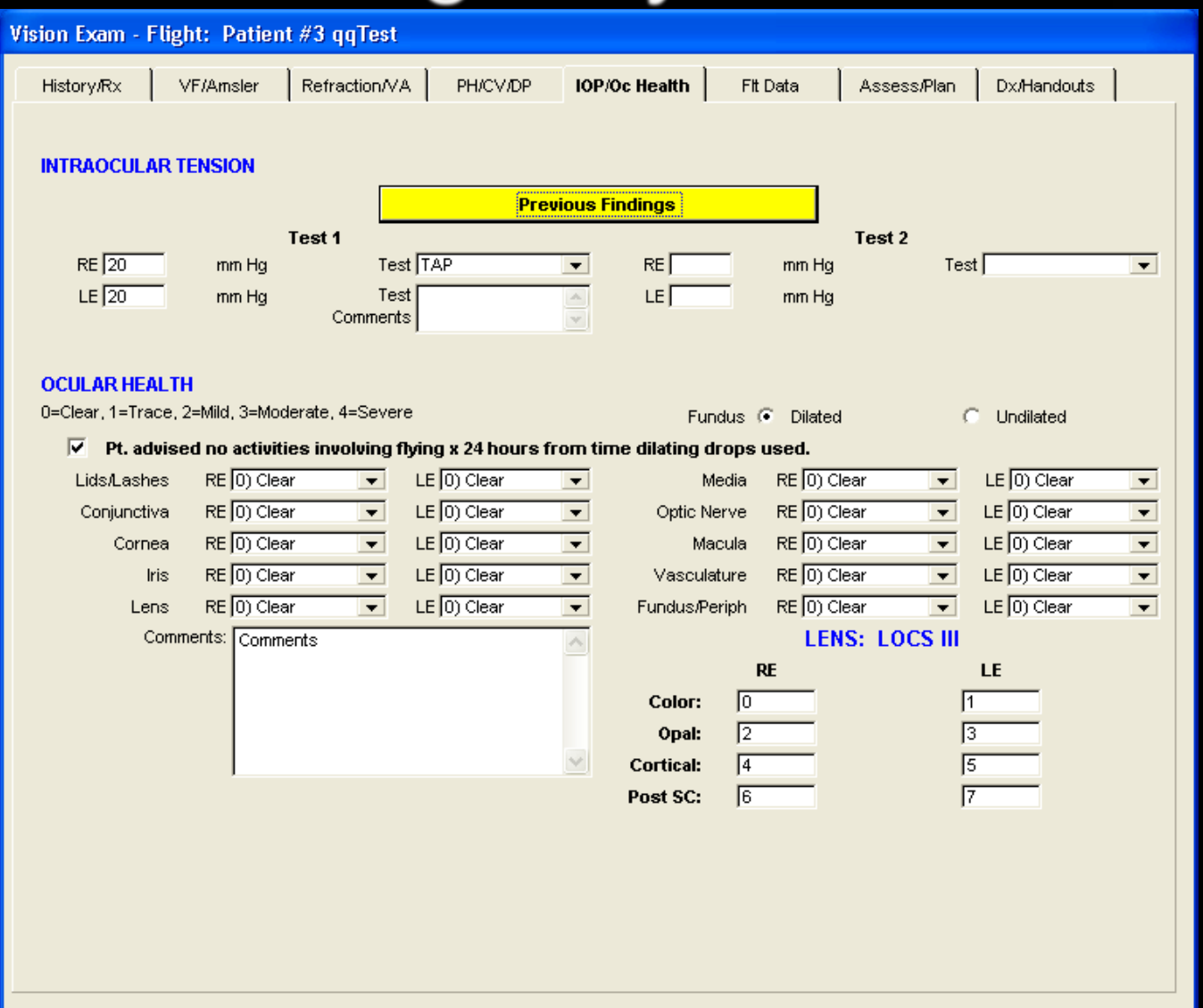
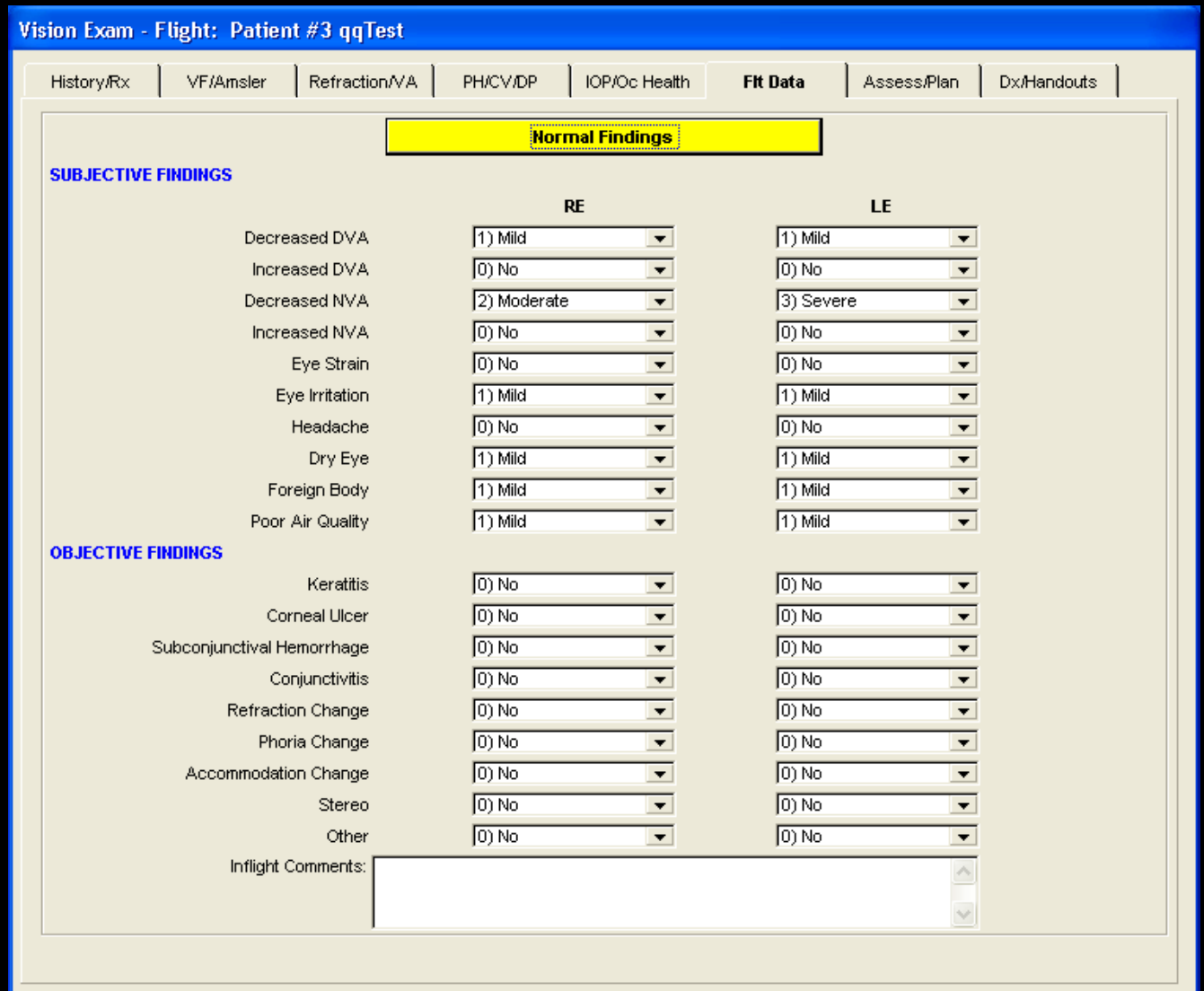
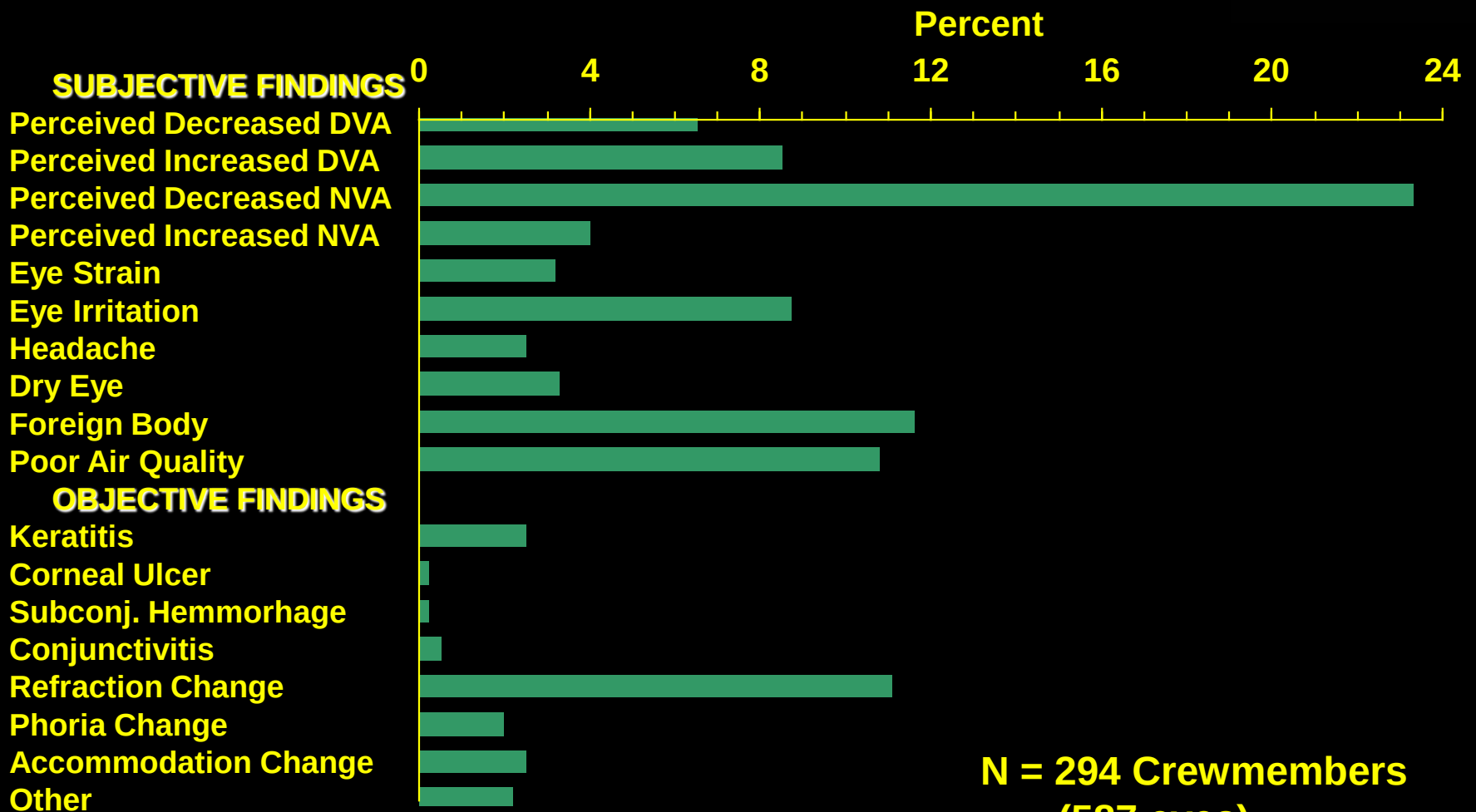


Annual, Preflight & Postflight Eye Exam



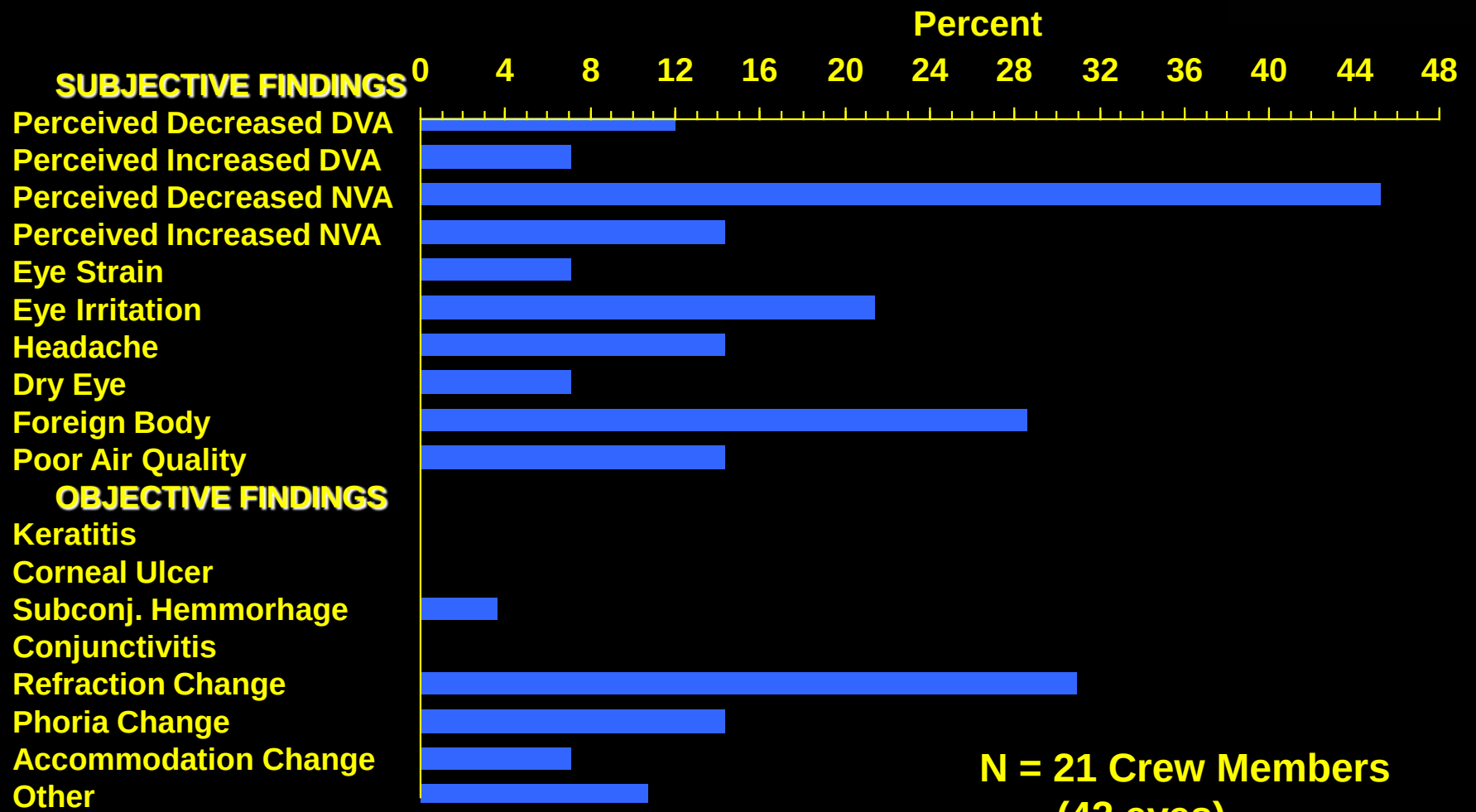
Annual, Preflight & Postflight Eye Exam

Postflight Ocular Findings
Shuttle Crew Members Only



N = 294 Crewmembers
(587 eyes)

Postflight Ocular Findings
ISS Expedition Crewmembers Only



N = 21 Crew Members
(42 eyes)

Preflight, In-Flight, & Postflight Testing (ISS)

Medical Requirements for long-duration space flight. Medical Evaluation Document (MEDB 1.10 Ophthalmology Exam):

- **Purpose/Objectives: To assess the status of ophthalmic health and function pre- and postflight.**
- **Flight Duration: ≥ to 30 days (4-6 months)**
- **Type of crew: All ISS primary crewmembers and backup crewmembers**
- **Test locations: Johnson Space Center, Coastal Eye Associates**

Preflight, In-Flight, & Postflight Testing (ISS)

Preflight Testing:

An eye examination will be conducted preflight by a specialist (L-90/45 days). The examination will include:

- **Refraction (cycloplegic)**
- **Best Corrected Visual Acuity**
- **Tonometry**
- **Automated Visual Fields**
- **Dilated Fundoscopy**
- **Contact Lens / Spectacle Storage Plan**
- **Amsler Grid Testing**
- **Pupil reflexes**
- **Extraocular muscle assessment**
- **Biomicroscopy (slit lamp)**
- **Retinal photography**
- **Optical coherence tomography (OCT)**
- **AScan**

Preflight, In-Flight, & Postflight Testing (Cont'd)

- In-Flight Testing: **None**

Preflight, In-Flight, & Postflight Testing (Cont'd)

Postflight Testing:

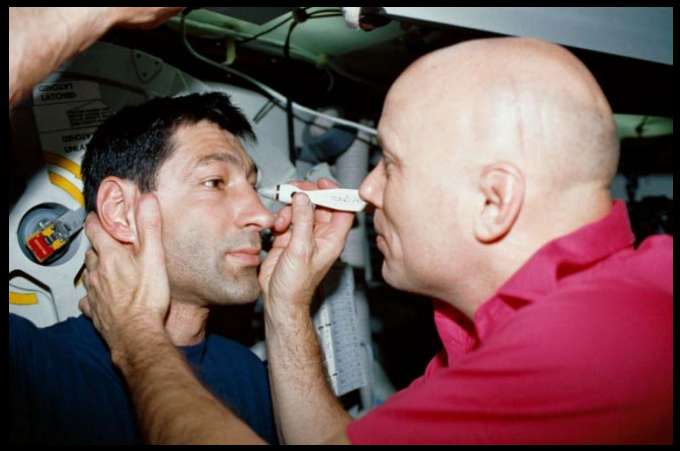
- R+0/1: Eye Examination, which includes ophthalmoscopic exam, conducted by flight surgeon.

- R+3 days (or ASAP): Eye examination conducted postflight by a specialist. The examination will include:

- Best Corrected Visual Acuity
- Tonometry
- Pupil Reflexes
- Extraocular Muscle Assessment
- Biomicroscopy (Slit Lamp)
- Survey
- Amsler Grid Testing
- Refraction(manifest and cycloplegic)
- Retinal photography
- Optical coherence tomography(OCT)
- AScan
- Automated Visual Fields
- Dilated Fundoscopy

Current In-Flight Capabilities (ISS)

- We currently have limited in-flight capabilities on board the International Space Station for performing an internal ocular health assessment.
  - Visual Acuity
  - Direct Ophthalmoscope
  - Ultrasound
  - Tonometry (Tonopen):



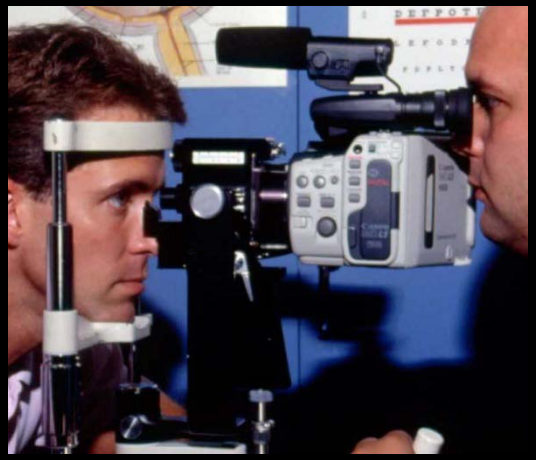
In-flight Recommendations

- Recommendations for minimal in-flight capabilities:
  - **Retinal Imaging** – provide in-flight capability for the visual monitoring of ocular health (specifically, imaging of the retina and optic nerve head) with the capability of downlinking video/still images.
  - **Tonometry** – provide more accurate and reliable in-flight capability for measuring intraocular pressure.
  - **Ultrasound** – explore capabilities of current on-board system for monitoring ocular health.

Past In-Flight Capabilities (STS)

- Shuttle Experiment (DSO 474) – Modified Kowa hand-held fundus camera

DSO 474 Retinal Photography (STS-34)



The video fundus camera integrated the Kowa RC-2 fundus camera with the Canon L-1 video camera. This configuration was used during STS-50 for a telemedicine downlink of retinal and optic nerve head video images.

Questions ?

NASA Vision Standards

4.6 EYES

1. Disease of either eye or supporting structure that may interfere with the performance of duties.

2. Lids and Ocular Adnexae

A. Any condition of the eyelids that impairs normal eyelid function.
B. Chronic blepharitis or blepharospasm.
C. Ptosis, unless benign etiology that is not progressive and does not interfere with vision in any field of gaze or direction.
D. Growths on the eyelid unless small, asymptomatic, non-progressive and benign.
E. Dacryocystitis or history of dacryocystitis.

3. Conjunctivae

A. Chronic or recurrent conjunctivitis requires ophthalmic evaluation.
B. History or presence of trachoma.
C. Xerophthalmia. Other dry eye syndromes require ophthalmic evaluation.
D. Pterygium that encroaches on the cornea more than 2 millimeters or recurs after two operative procedures.

4. Cornea

A. Chronic or recurrent keratitis requires ophthalmic evaluation.
B. History of corneal ulcer or erosion requires ophthalmic evaluation.
C. Herpetic ulcer or history of herpetic ulcer.
D. Vascularization, haze, or opacification of the cornea from any cause when it is progressive or interferes with vision.
E. Corneal dystrophy of any type, including keratoconus of any degree.
F. History of orthokeratology treatments within the previous six months. Prior orthokeratology requires ophthalmic evaluation.
G. History of penetrating or lamellar keratoplasty.

NASA Vision Standards

H. Corneal implantation.
I. Refractive surgical procedures other than the following:
a. PRK or any variant of excimer laser surface procedures
1. Pre-op cycloplegic refractive error shall be between +4.00 to -8.0 sphere and astigmatism shall be 3.00 D or less in minus cylinder format.
2. No less than 1 year post-op (including enhancements) with no permanent adverse sequelae
b. LASIK
1. Pre-op cycloplegic refractive error shall be between +4.00 to -8.0 sphere and astigmatism shall be 3.00 D or less in minus cylinder format.
2. No less than 1 year post-op (including enhancements) with no permanent adverse sequelae

5. Uveal Tract
A. Acute, chronic or recurrent inflammation of the uveal tract (iris, ciliary body, choroid). History of uncomplicated post-traumatic iritis requires ophthalmic evaluation.

6. Retina and Vitreous
A. History or presence of retinal detachment, unless traumatic with no sequelae, retinal tears, or edema.
B. Retinal hole with presence of fluid or vitreous traction. Other retinal holes require ophthalmic evaluation.
C. Degeneration or dystrophies of the central or peripheral retina, including lattice degeneration, require ophthalmic evaluation.
D. Pigmentary degeneration requires ophthalmic evaluation.
E. Retinitis, chorioretinitis, or other inflammatory conditions of the retina, unless single episode which has healed and does not impair central or peripheral vision.
F. Hemorrhages, exudates, or other retinal vascular conditions that potentially impair vision require ophthalmic evaluation.
G. Vitreous opacities or conditions that may cause loss of central acuity or peripheral visual field require ophthalmic evaluation.

NASA Vision Standards

7. Optic Nerve
A. Presence or history of optic neuritis.
B. Optic atrophy, primary or secondary.
C. History of papilledema, pseudopapilledema, or papillitis requires ophthalmic evaluation.
D. Congenito-hereditary conditions, including optic nerve drusen, that may interfere with central visual acuity or visual field.
8. Lens
A. Aphakia.
B. Lens opacities that interfere with vision or are considered progressive require ophthalmic evaluation.
C. Lens dislocation, partial or complete.
D. Intraocular implants or intraocular contact lenses.

9. Other Defects and Disorders
A. History or presence of malignant tumors in the eye or orbit.
B. Resected basal cell cancers or benign tumors require ophthalmic evaluation.
C. Exophthalmos, anophthalmos or microphthalmos.
D. Pathologic nystagmus.
E. Diplopia.
F. Abnormal pupil(s) or loss of normal pupillary reflexes requires ophthalmic evaluation.
G. Coloboma.
H. Any organic or congenital disorder of the eye or adnexa not previously specified that threatens to impair visual function.

NASA Vision Standards

10. Refractive standards: inability to meet the following refractive standards

A. Near and distant vision uncorrected or correctable to 20/20 or better in each eye.

B. Refractive error: (distant vision): Pilot

1. Cyclopegic refractive error of more than +3.50 or -4.00 diopters in any meridian.
2. Astigmatism requiring more than 2.00 diopters of cylinder correction.
3. Anisometropia of more than 2.50 diopters

C. Refractive error: (distant vision): MS, PS, and SFP

1. Cyclopegic refractive error of more than +5.50 or -5.50 diopters in any meridian.
2. Astigmatism requiring more than 3.00 diopters of cylinder correction.
3. Anisometropia of more than 3.50 diopters

11. Visual Fields: All visual field defects require ophthalmic evaluation.

12. Extraocular muscle balance

A. Esophoria greater than 10 prism diopters measured at 6 meters.

B. Exophoria greater than 10 prism diopters measured at 6 meters.

C. Hyperphoria greater than 2 prism diopters measured at 6 meters.

D. Any heterotropia measured at any distance.

E Point of convergence (PC) greater than 100 millimeters requires ophthalmic evaluation.

F. Paralysis of ocular motion in any field of gaze.

G. Any diplopia or suppression in the red lens test that develops within 50.8 centimeters (20 inches) from the center of the screen in any of six cardinal directions requires ophthalmic evaluation.

NASA Vision Standards

13. Depth Perception: Lack of adequate stereopsis on objective testing. (Candidates must pass the Optec 2300 depth-perception or Verhoeff or Randot tests.)

14. Unsatisfactory night vision as determined by history and confirmed by objective testing.

15. Color Vision Deficiency: Inability to pass red-green or blue-yellow color vision testing.

16. Intraocular Pressure

A. Glaucoma, identified by pressure greater than 30 mmHg in either eye, characteristic glaucomatous change in the optic nerve or visual field loss characteristic of glaucoma.

B. Preglaucoma, identified by pressure on two determinations equal to or greater than 25 mmHg or a difference greater than 4 mmHg between eyes.

C. Pigmentary Dispersion Syndrome requires ophthalmic evaluation.

17. Medically required use of a contact lens.