Visiting Hubble in Orbit

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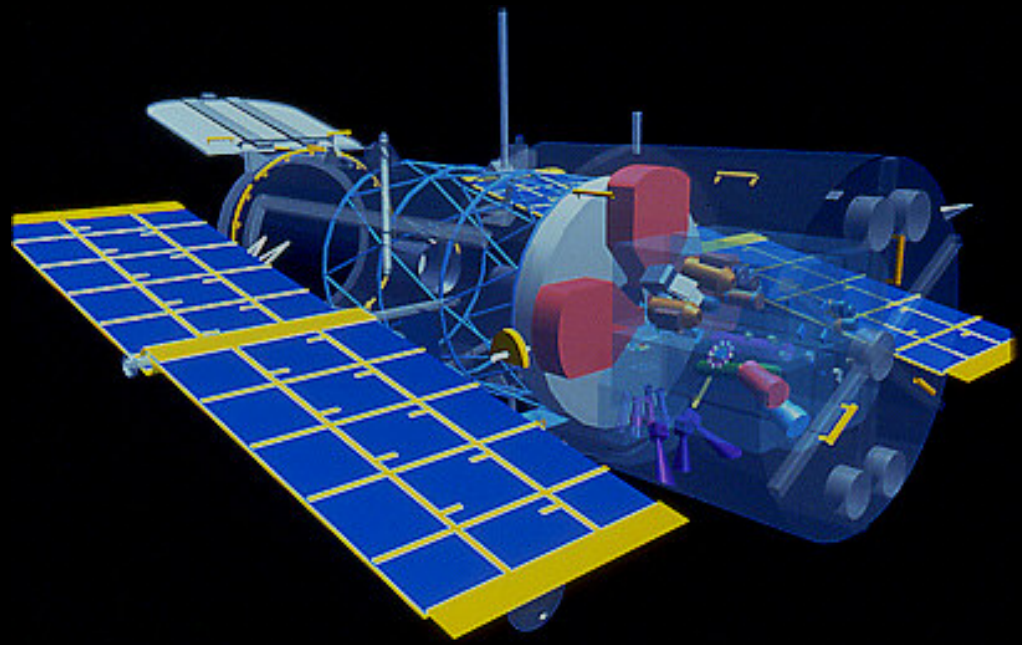
Outline

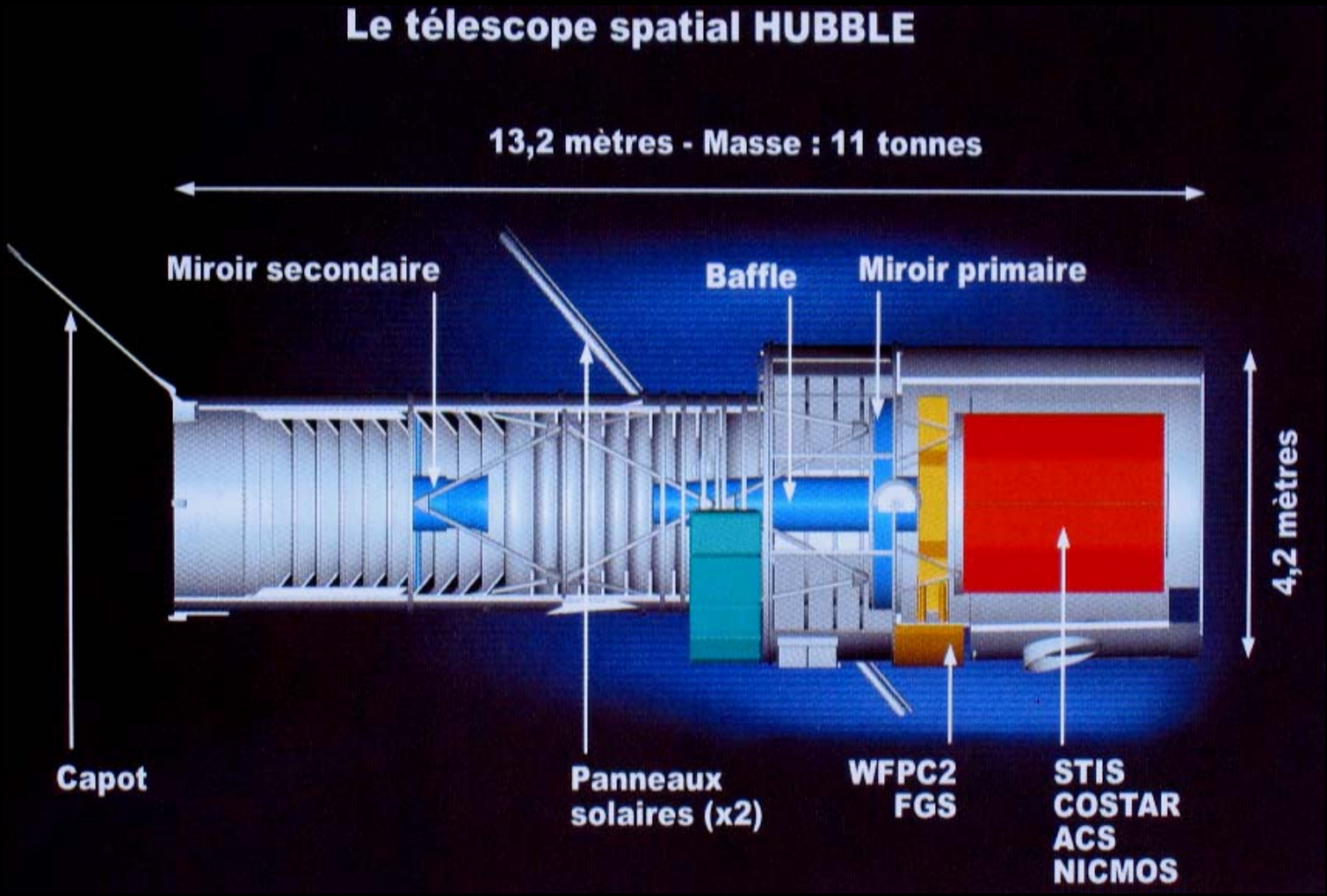
- A little bit of history…
- Servicing Missions 1 and 3A, with emphasis on the rendezvous and EVA phases
- The challenge of working while spacewalking
- Success and gratification…
- Servicing Mission 4 and future plans

Hubble

NASA/ESA



Le télescope spatial HUBBLE



Hubble into orbit

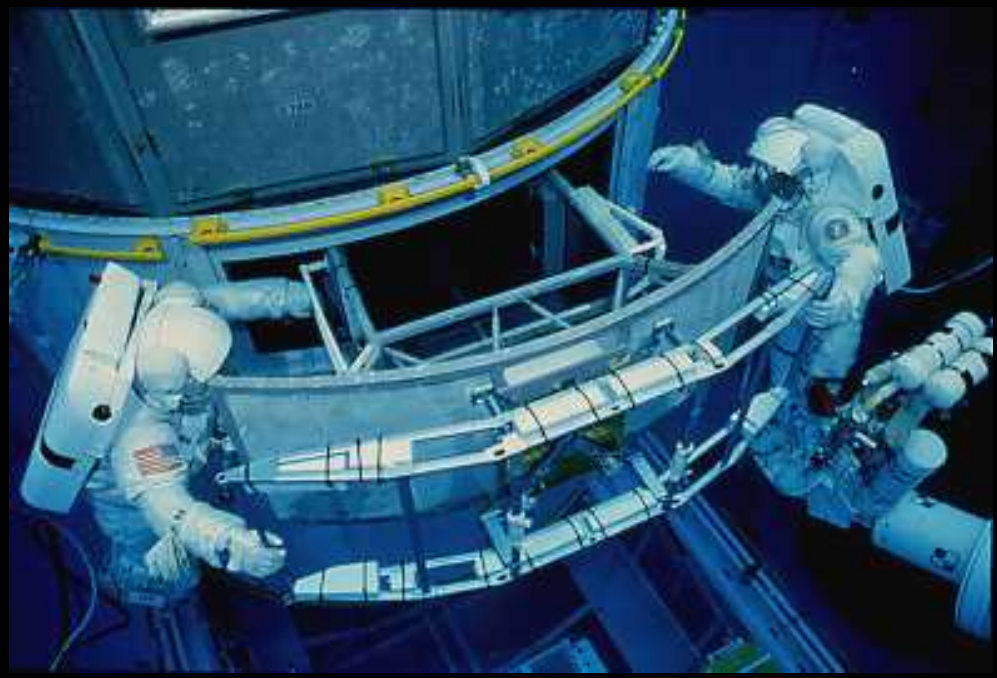
April 1990


SM 1 in Dec. 1993
SM 2 in Feb. 1997
SM3A in Dec. 1999
SM 3B in Mar. 2002

SM 1 and 3A


MUSGRAVE
COVEY
BOWERSOX
AKERS
HOFFMAN
NICOLLIER
THORNTON

First use of a VR capability at JSC to set up robotic/EVA servicing scenarios



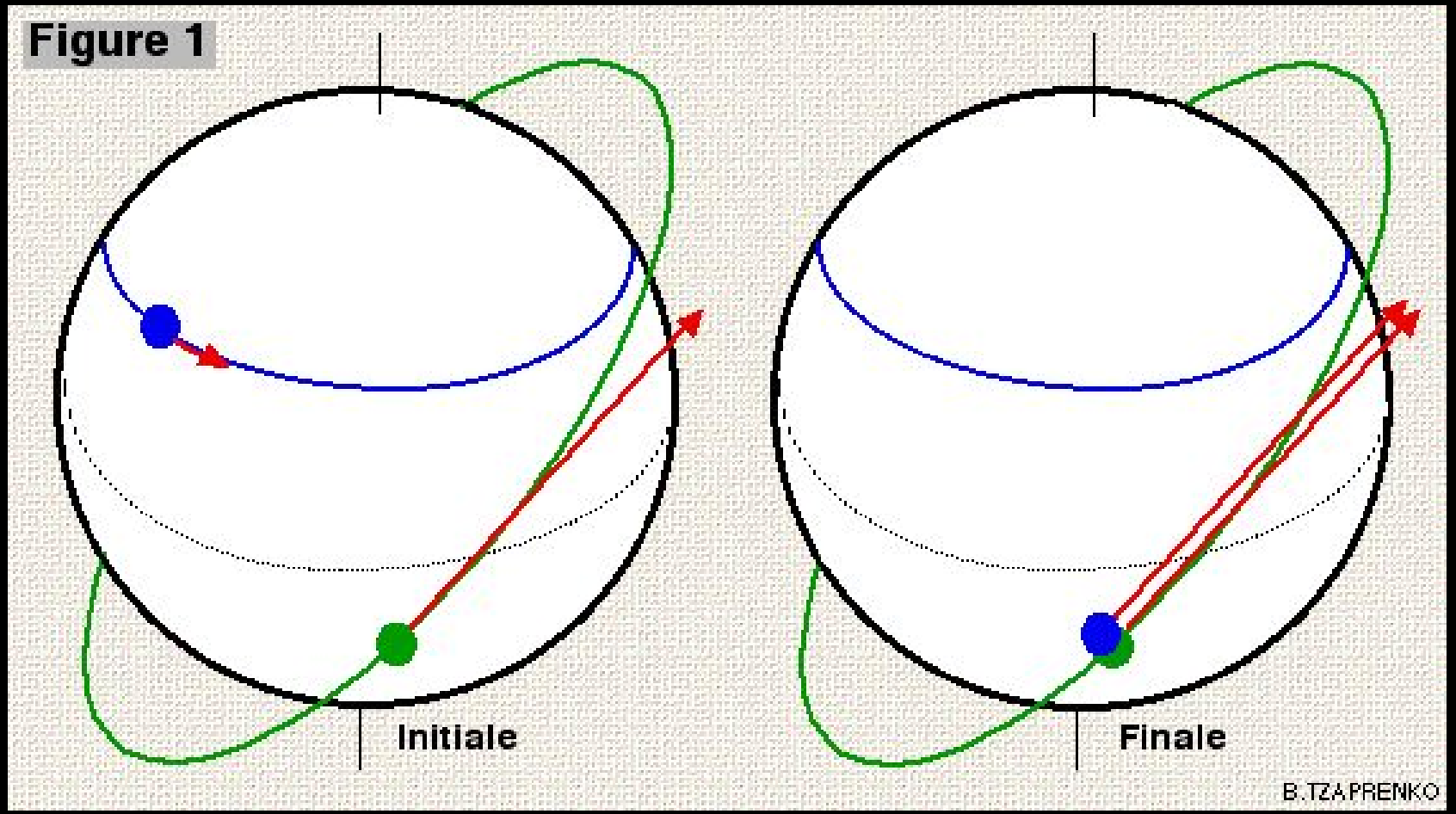
EVA training at MSFC in Huntsville (Alabama)


NASA
SIDE 1
SIDE 1

On the way to Hubble

December 2nd, 1993

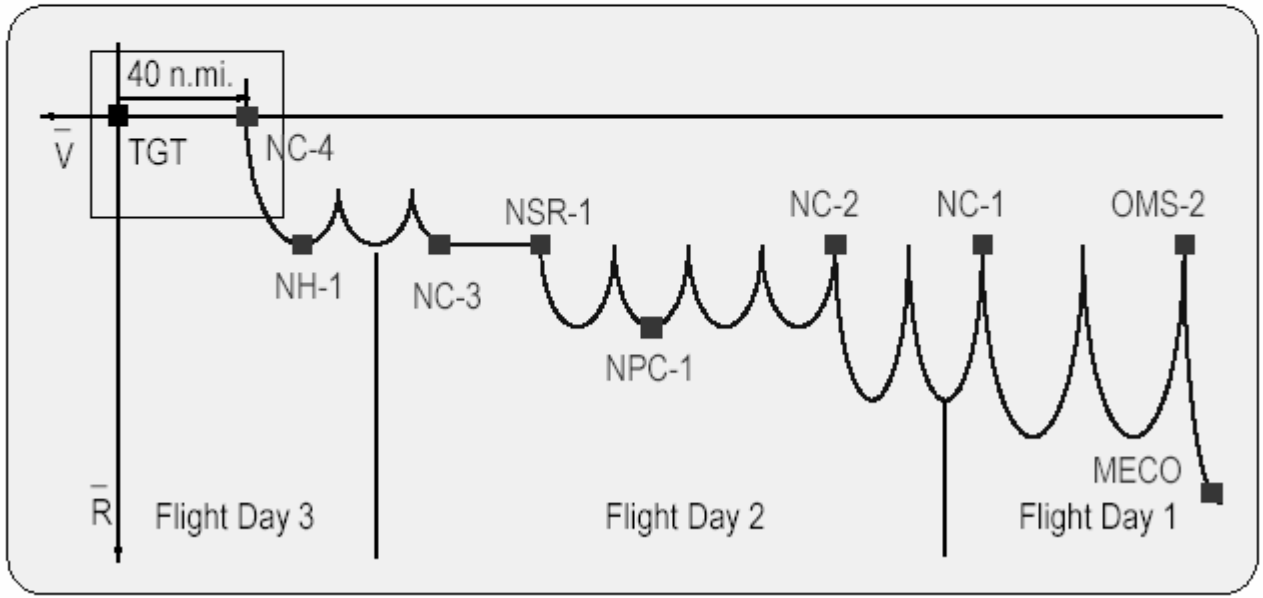
Rendez-vous



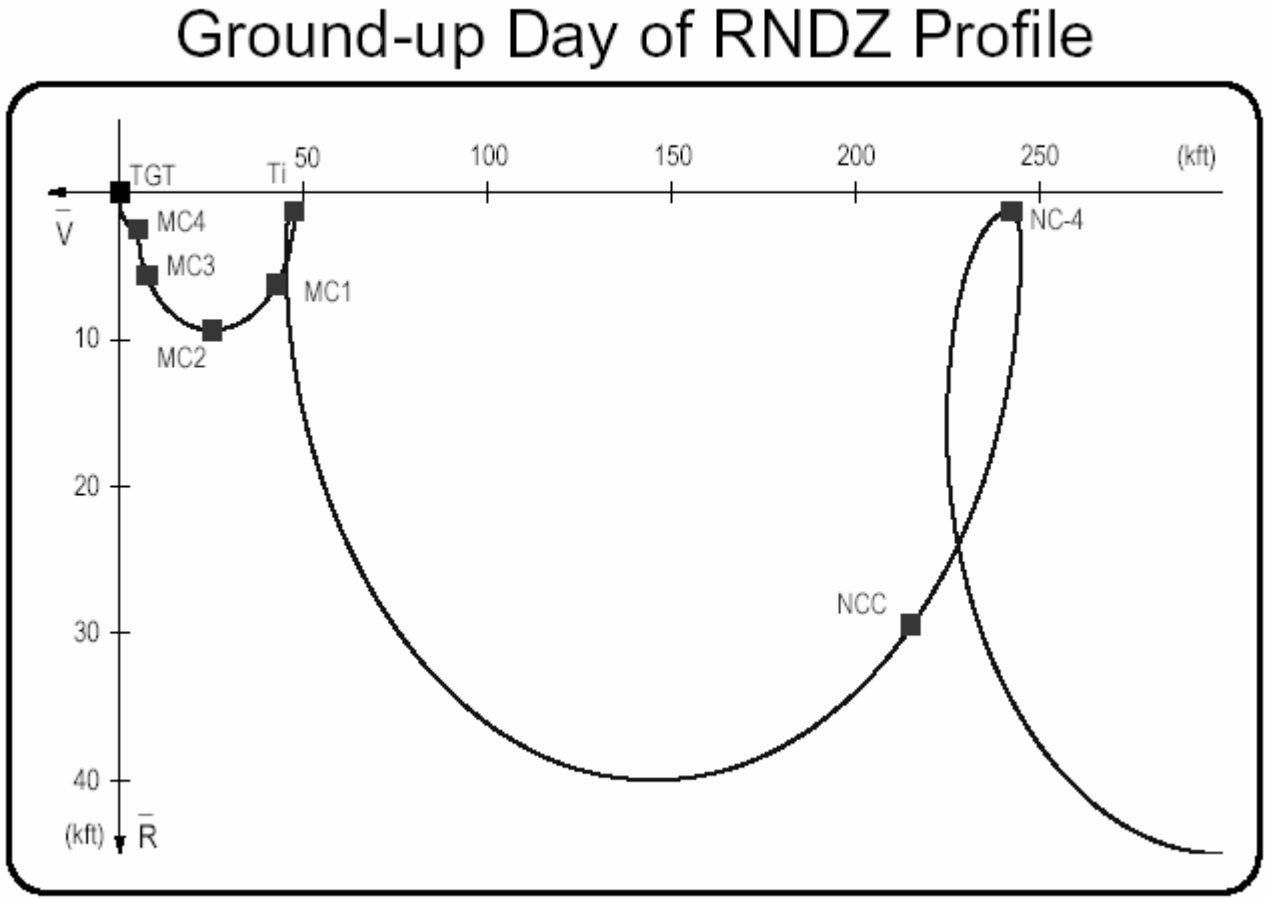
Rendez-vous

Ground-up RNDZ

- **OMS-2 used as a phasing burn**
- **All burns designed posigrade for efficiency**
- **Sets up standard day-of-rendezvous on FD3 or 4 with orbiter 40 n.mi. behind the TGT near orbital noon**



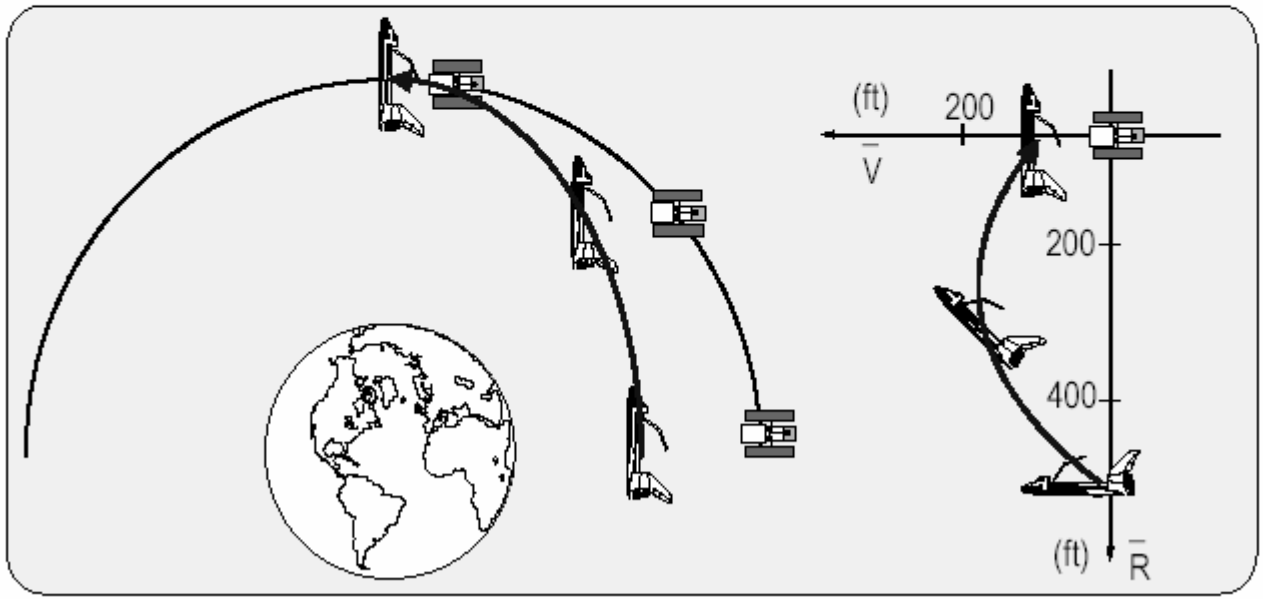
Rendez-vous

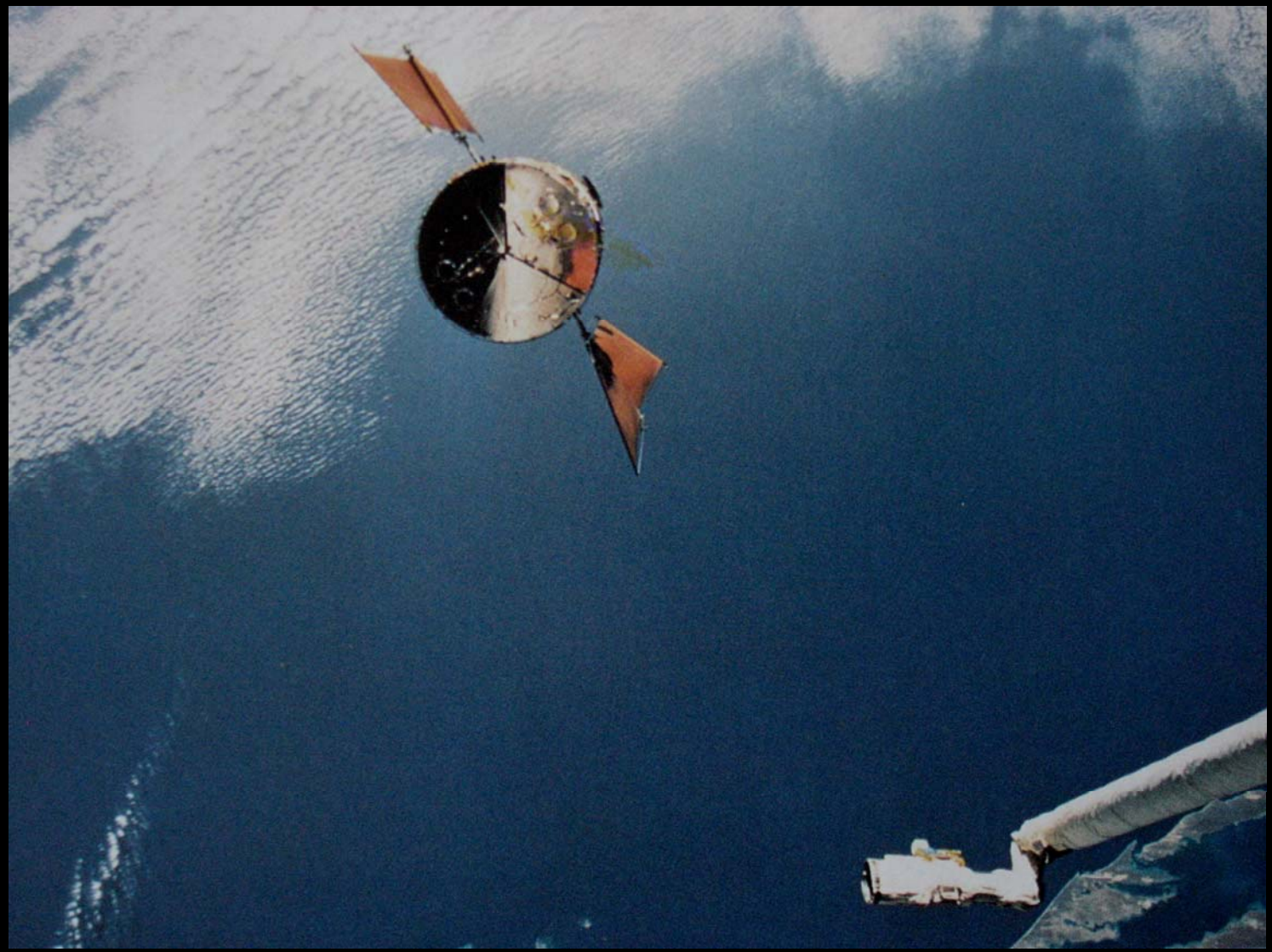

Ground-up Day of RNDZ Profile
TGT
Ti
50
100
150
200
250
(kft)
V̄
MC4
MC3
MC2
MC1
NC-4
NCC
10
20
30
40
(kft)
R̄

Rendez-vous

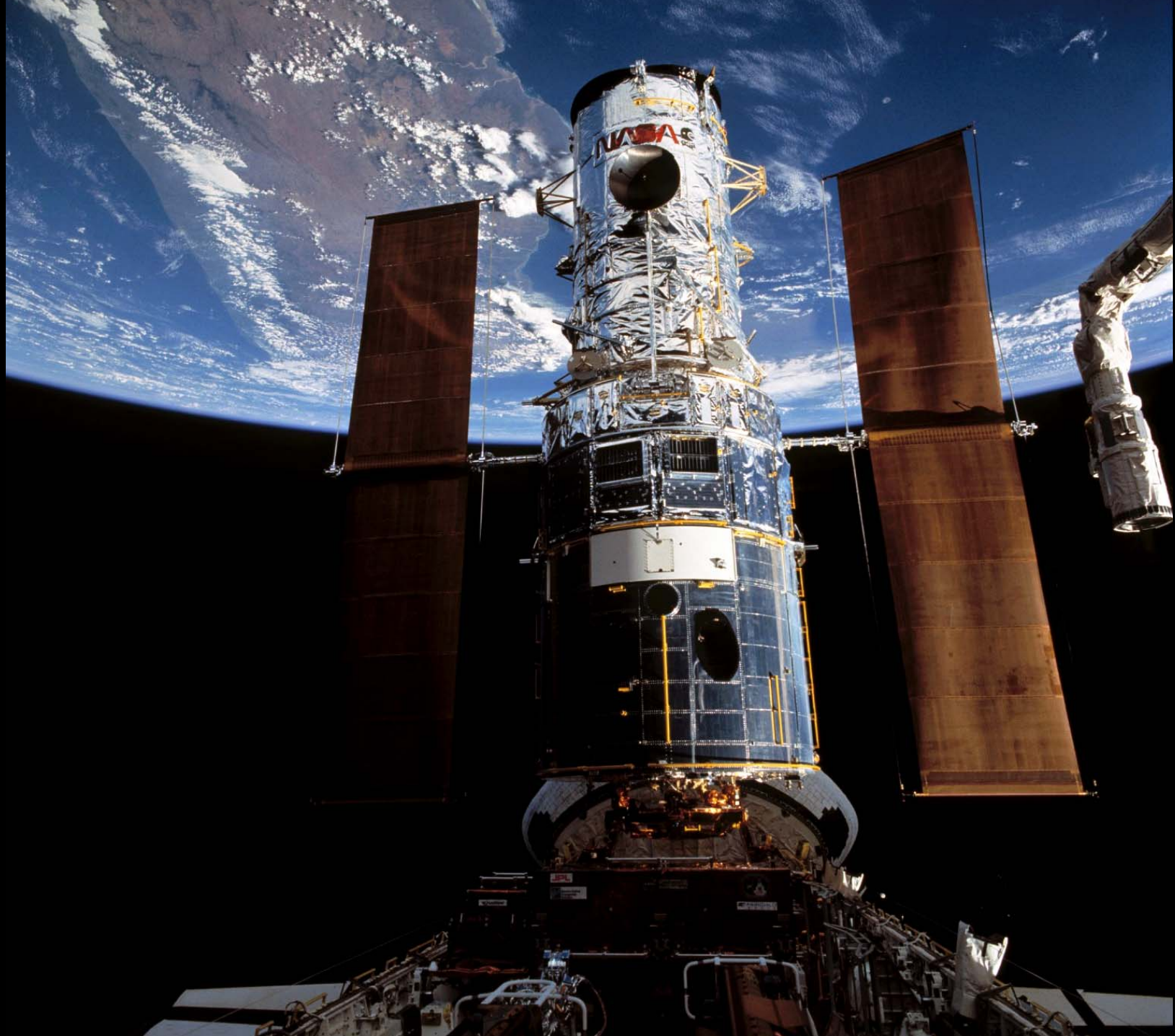
Inertial Approach

- **Inertial approach**
  - **Used with large inertially-stabilized TGT**
  - **Orbiter in INRTL attitude hold**
  - **Orbital mechanics effects vary during approach**

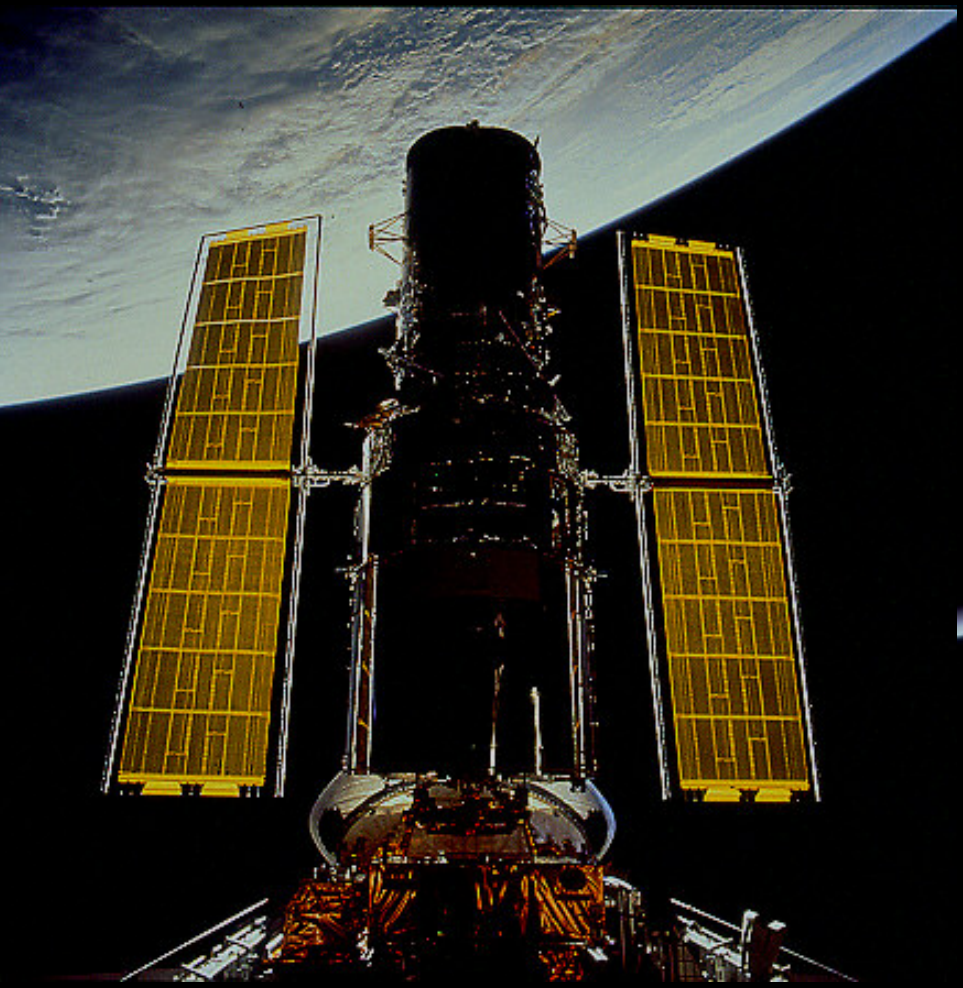




Final rendezvous with Hubble at MET around 2 days, 600 km altitude




NASA



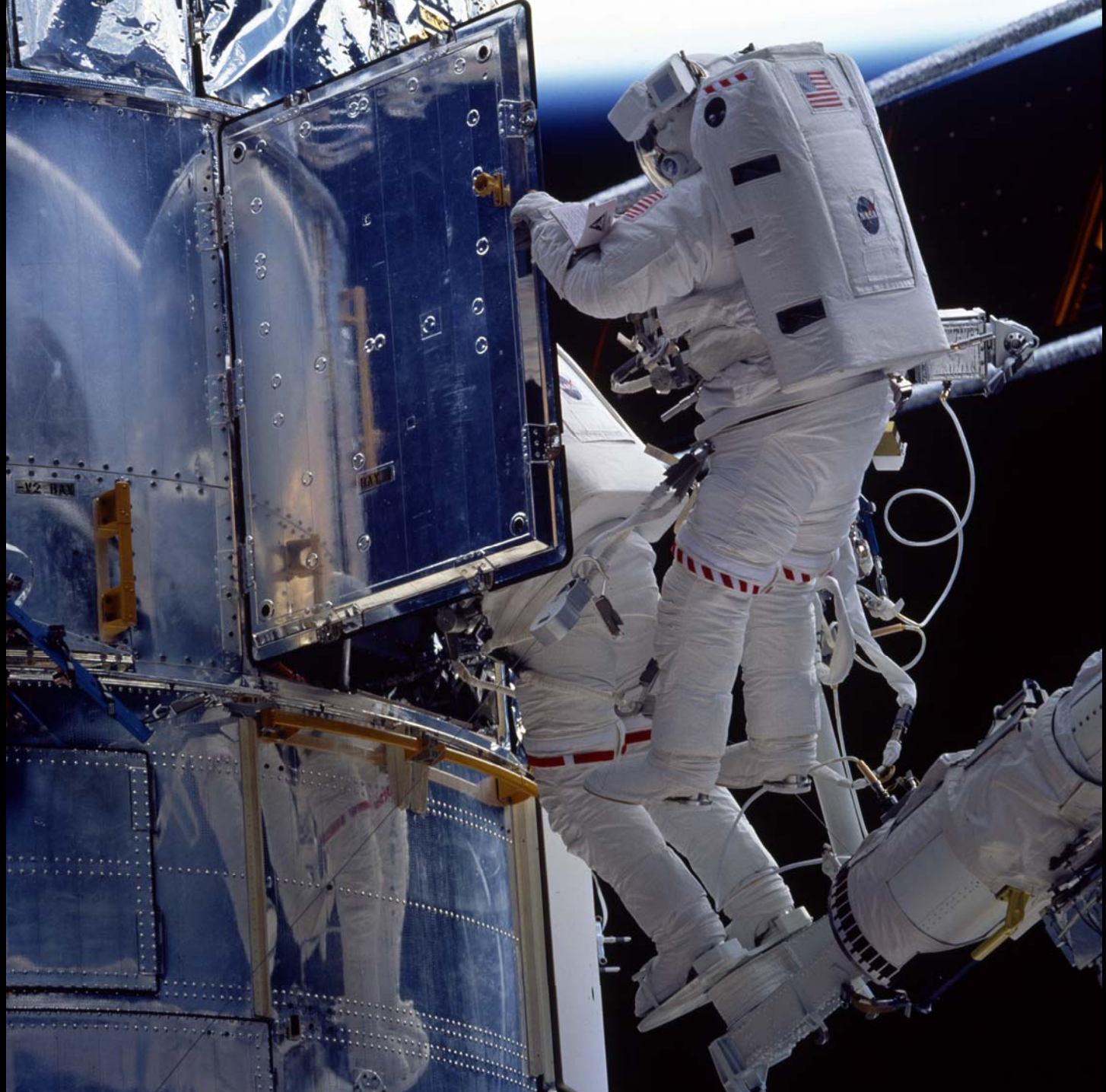
STS-61, Freude herrscht!!


CLERVOY BROWN KELLY
GRUNSFELD SMITH FOALE NICOLLIER

… back in a significantly upgraded VR Lab at JSC


EYE GLASSES
WRISTBITS
LEFT GLOVES
RIGHT GLOVES


NASA
GODDARD SPACE FLIGHT CENTER




STS-103
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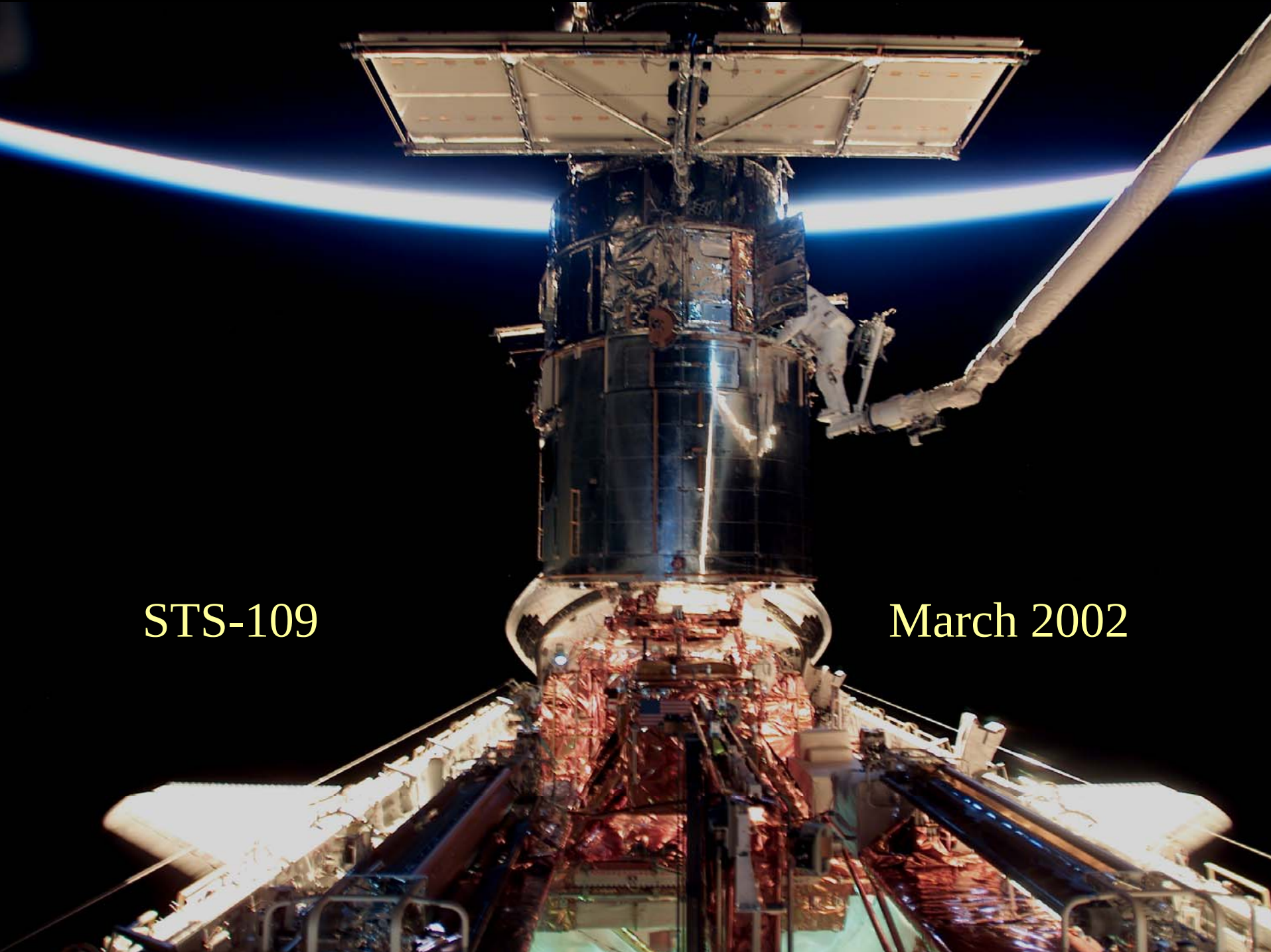
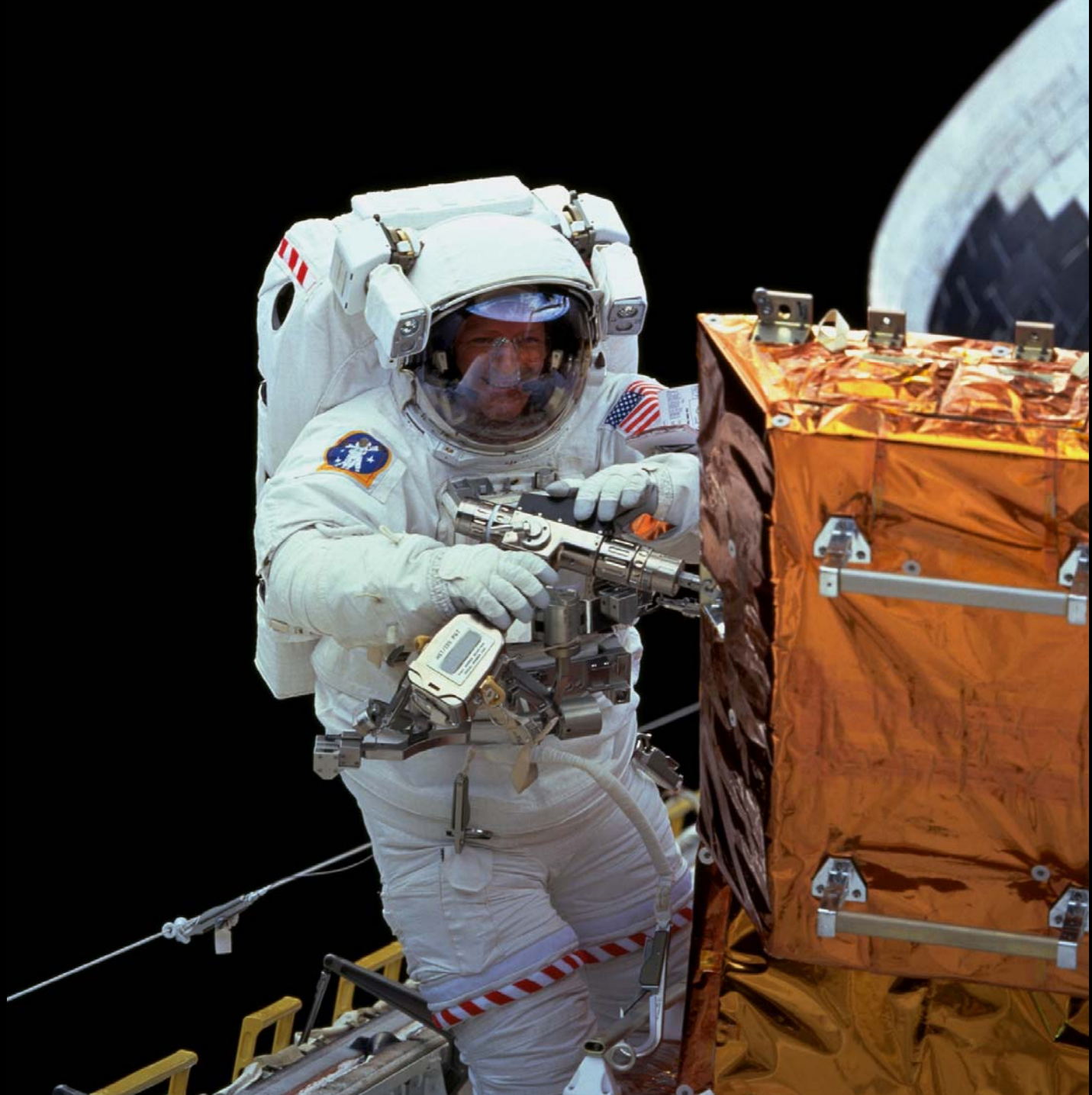

STS-109
March 2002

The challenge of working while spacewalking

Golden Rules for Spacewalkers

- Don’t do it if you are claustrophobic…
- Stabilize your body to do any useful work
- Take appropriate measures so as not to let anything go free because tools, instruments and astronauts are useless if they are lost in space
- Don’t rush… you’ll waste time and you might lose control

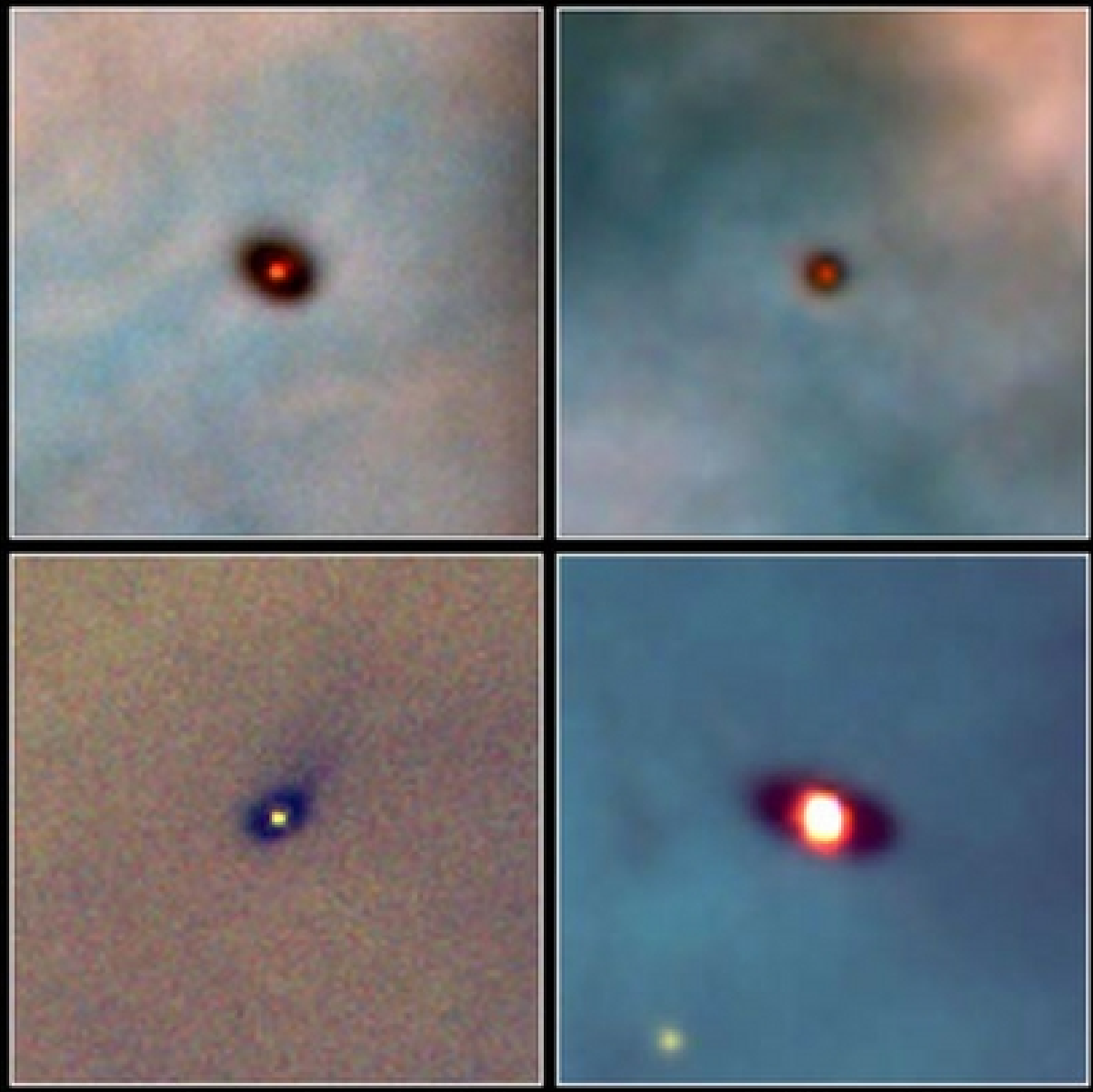


Success and gratification…

Success through

- Clear goals, well defined priorities, teamwork
- Strict operational dicipline
- Get ready to cope with the unforeseen and undesirable
- Train, train, and retrain...

…the gratification…



Protoplanetary Disks
Orion Nebula

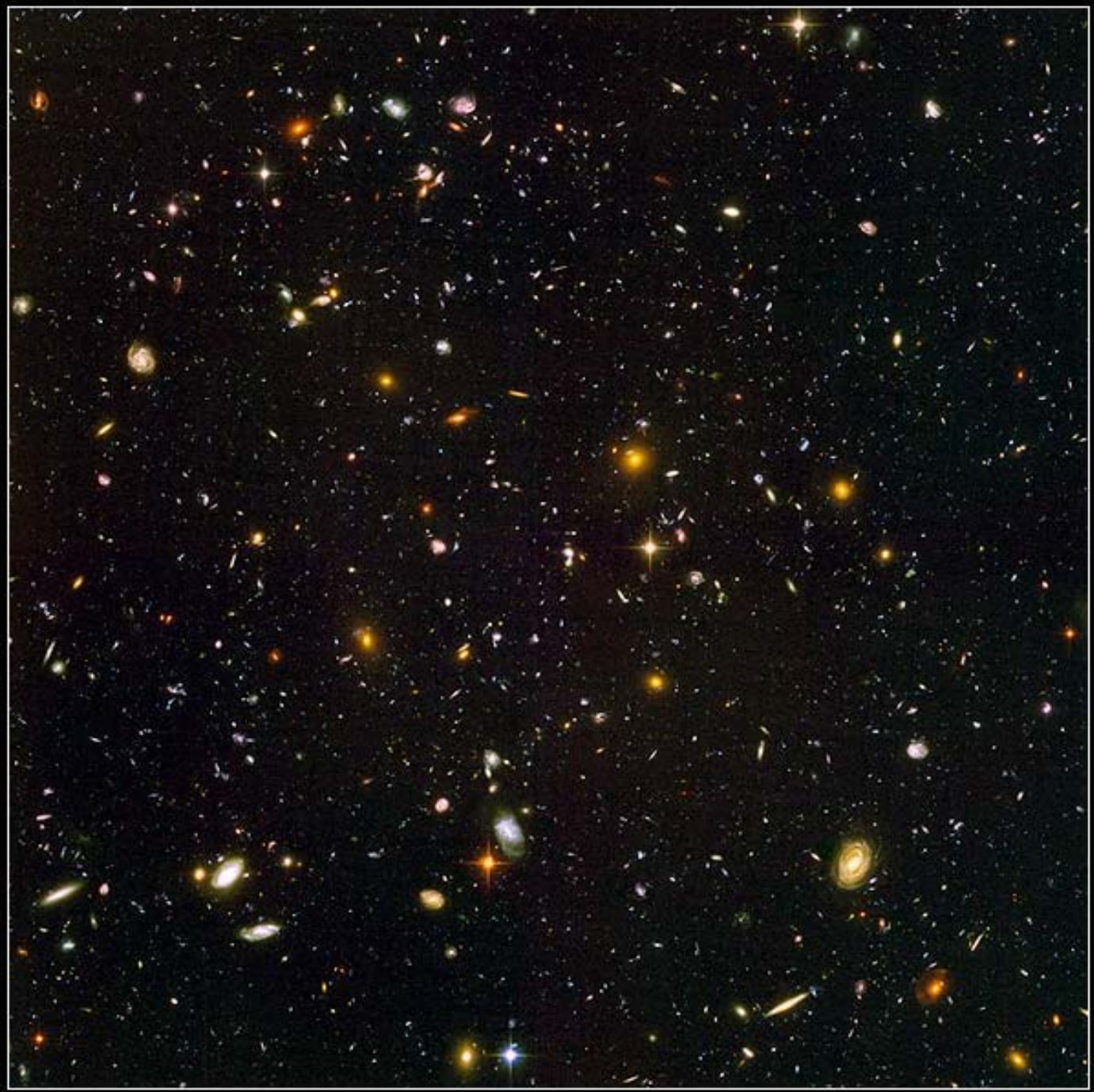
HST • WFPC2

PRC95-45b • ST ScI OPO • November 20, 1995
M. J. McCaughrean (MPIA), C. R. O'Dell (Rice University), NASA

Cat's Eye Nebula • NGC 6543

Hubble Ultra Deep Field

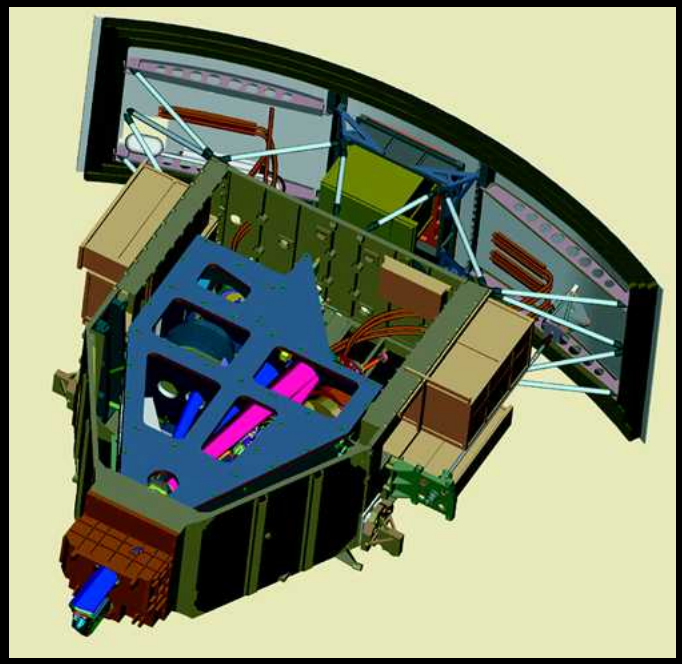
HST ▪ ACS



SM 4 and future plans

SM 4 tasks

- Install WFC-3 (Hi Res camera near IR - UV)
- Install COS (UV spectrograph)
- Repair STIS (Imaging spectrograph)
- Replace all 6 RSUs (rate Sensor Units)
- Replace batteries (NiH2 type)
- Install soft capture mechanism (for future use)
- Install over-voltage protection kits



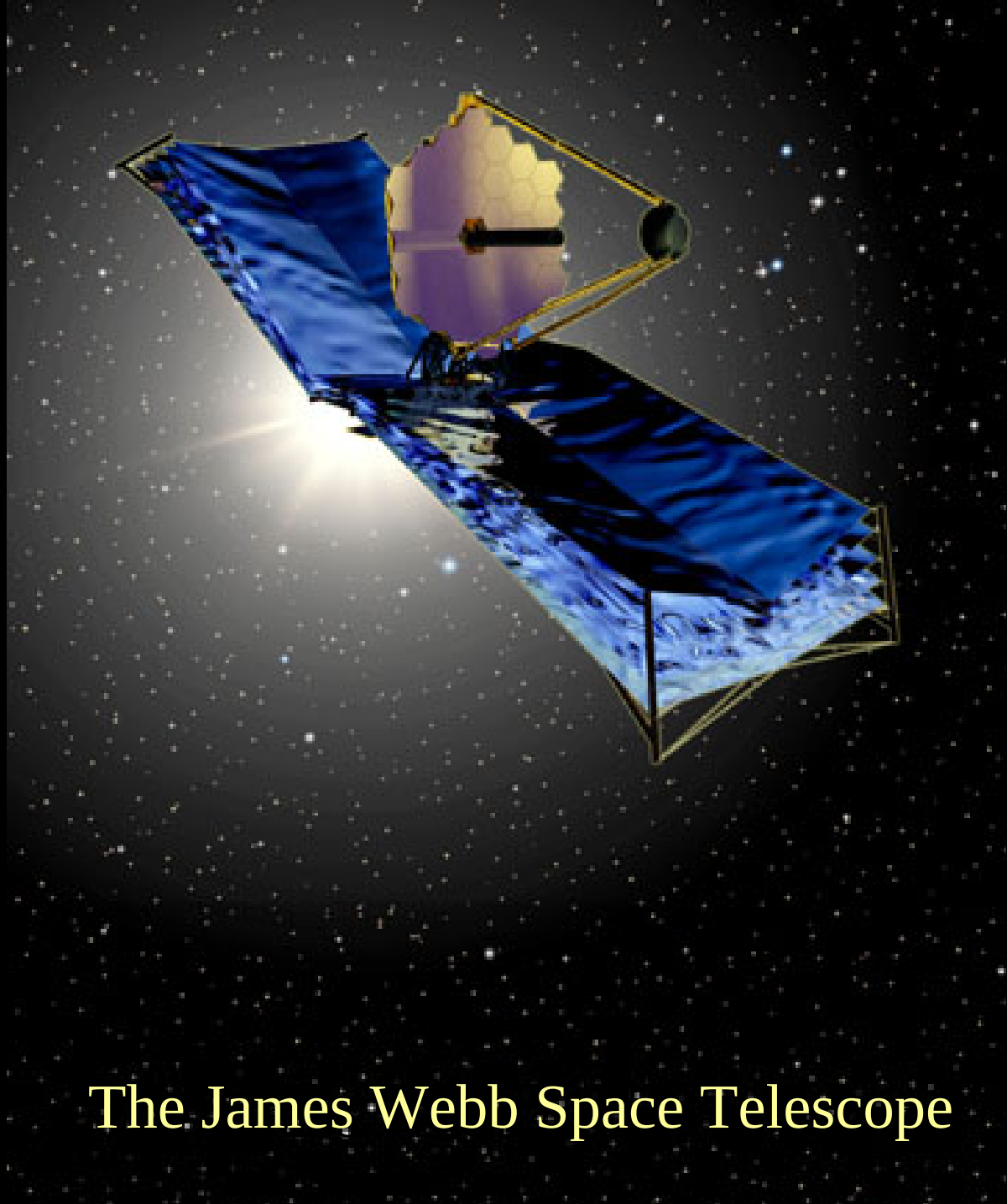
WFC 3

RSU (3X)

batteries

STIS

...the SM 4 crew.....



The James Webb Space Telescope

…in the meanwhile -
my very best wishes
for many more years
of productive Hubble
utilization…