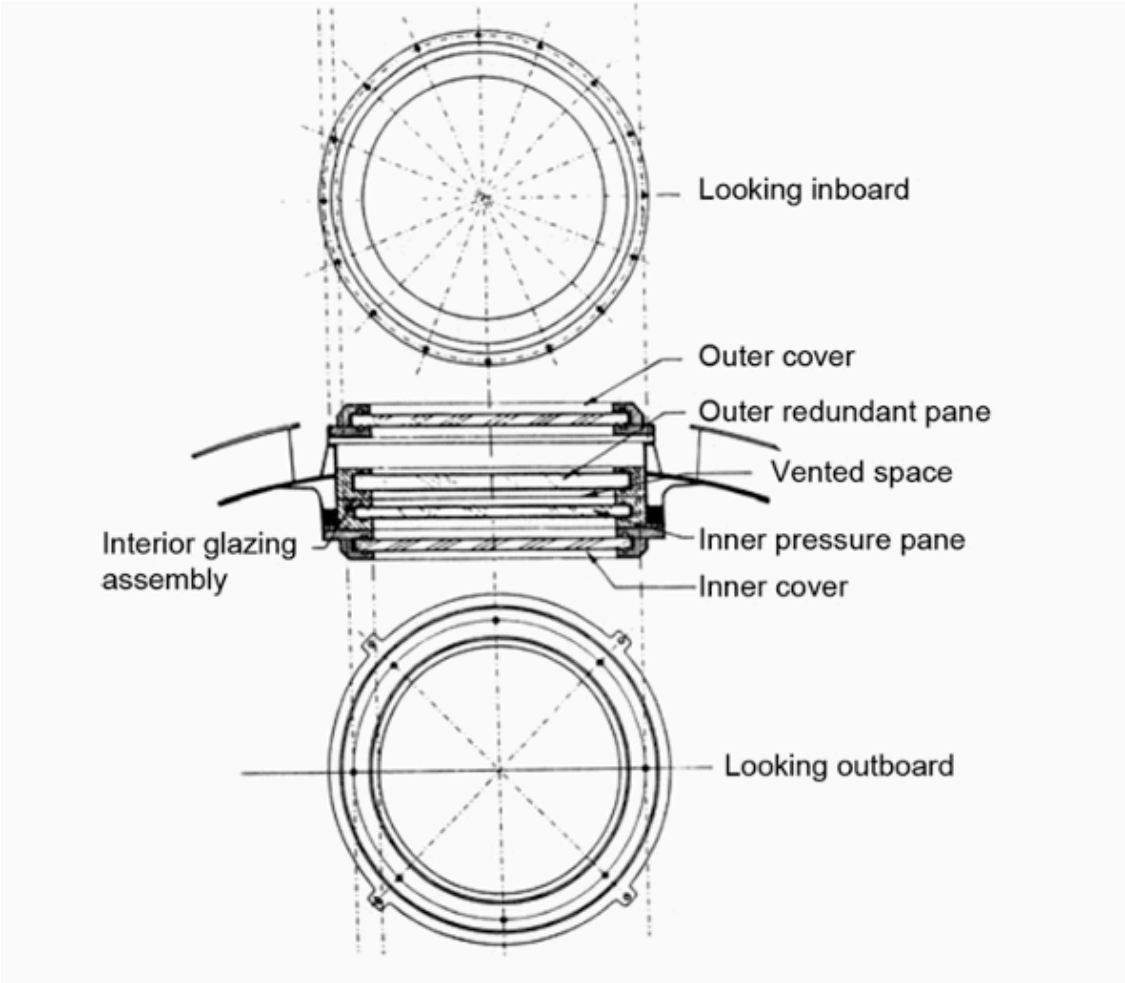

The Cupola Observation Module The Cupola module was launched to the International Space Station in 2010. It is an attachment to Node 2 and provides a 360-degrees observation and control capacity for the robotic arm and other outside operations. The module is a pressurized observation and work zone with command and control workstations and other hardware. It has seven windows with protective shutters (Fig. 5.15). The cupola has a height of 1.4 m (4.7 ft) with a diameter of about 3 m.

Radiation Shielding Outer space, Lunar, and Mars surface habitats and crews must be protected from micrometeoroid and radiation hazards with levels 'As Low As Reasonably Achievable' (ALARA). With regard to micrometeoroids, the goal is to afford a 0.993 "probability of no penetration" (PMP) over each 5 year period. While no firm radiation dose limits have been established for exploratory class missions, those which have been applied for low-Earth orbit (LEO)

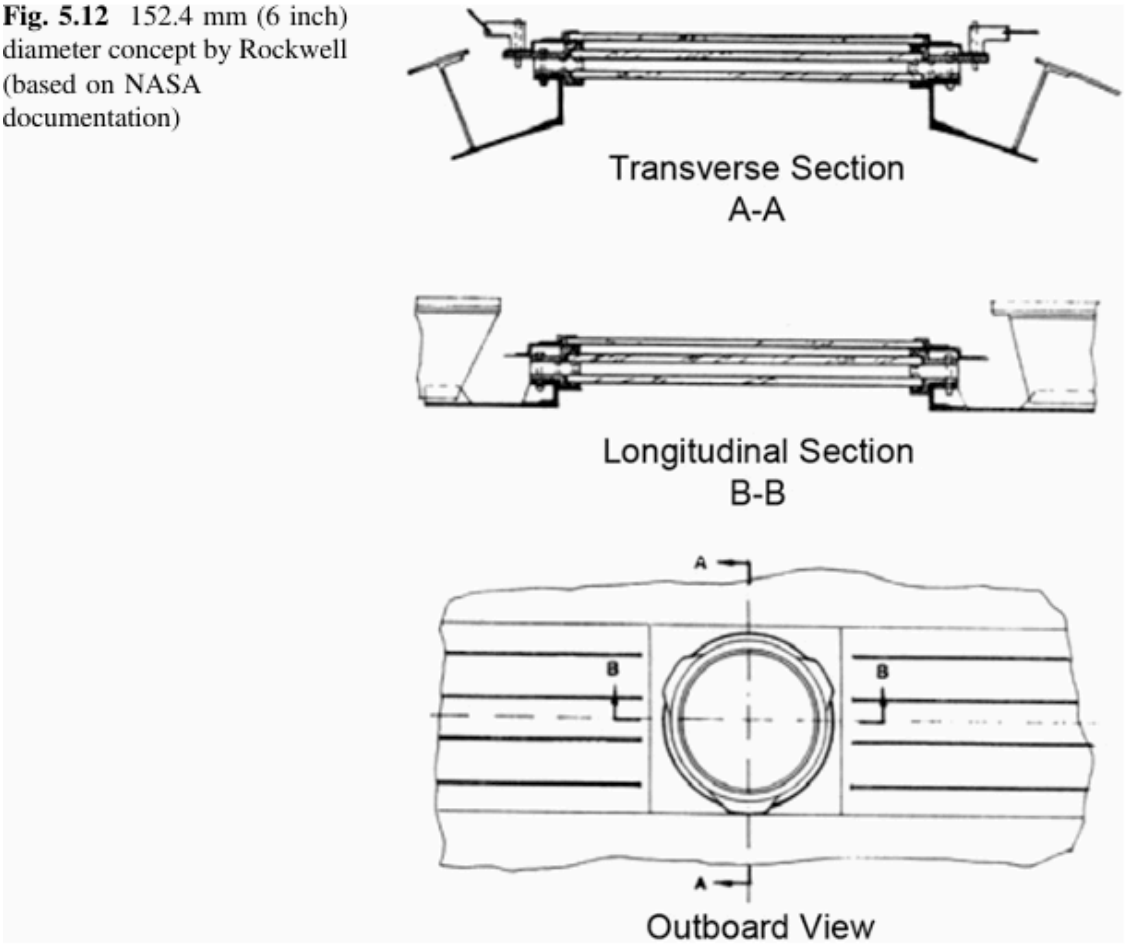

Fig. 5.12 152.4 mm (6 inch) diameter concept by Rockwell (based on NASA documentation)

Table 5.9 Recommended NCRP radiation dose limits (mGy—milliGray, mGy-Eq—milliGray equivalent) Organ 30 day limit Lens* (mGy-Eq) Skin BFO Heart** CNS*** 1000 1500 250 250

1 year limit 2000 3000 Career 4000 4000 500 500 500 CNS*** ($Z \geq 10$) 1000 100 mGy Not applicable 1000 1500 250 mGy *Lens limits are intended to prevent early (< 5 yr) severe cataracts (e.g., from a solar particle event). An additional cataract risk exists at lower doses from cosmic rays for subclinical cataracts, which may progress to severe types after long latency (> 5 yr) and are not preventable by existing mitigation measures; however, they are deemed an acceptable risk to the program

**Heart dose calculated as average over heart muscle and adjacent arteries

***Central Nervous System (CNS) limits should be calculated at the hippocampus.

Available with current technologies and potential ISRU applications Water shelters: deployable and permanent Regolith Polyethylene Natural landscape Emerging technologies MF (Magnetic Field)

shielding using superconducting magnets ION shielding Nanotubes (hydrophobic or hydrophilic) Lava tubes (would require advanced technologies)