missions with smaller budgets and/or the allocation of funds to the balance-of-spacecraft. This is an essential attribute in enabling such missions as the Mars Outpost SEP Tug. An example of the benefits of thin-film PV arrays for the now-canceled ST4/Champollion indicates a $50 million launch cost savings and 30% mass margin increase when thin-film solar array power generation was combined with advanced electric propulsion. A parametric assessment showed similar advantages for other solar system missions (e.g. main belt asteroid tour, Mars SEP vehicle, Jupiter orbiter, Venus orbiter, Lunar surface power system) [30].

Much of the original development of thin-film PV arrays was performed with the terrestrial marketplace in mind. This has been a tremendous benefit to researchers hoping to develop such arrays for space. Features such as cell efficiency, material stability and compatibility, and low-cost and scalable manufacturing techniques are important to both environments. However, many key array aspects necessary for space utilization are not important for terrestrial use and thus have not experienced a similar progress. Features such as radiation tolerance, air mass zero (AM0) performance, use of lightweight flexible substrates, stowed volume and lightweight space deployment mechanisms must be developed before a viable space array can become a reality. Unfortunately, the costs associated with developing these features along with the subsequent space qualification studies mitigate the savings of using a thin-film array for space, and thus have inhibited their application.

On-going efforts by NASA and the U.S. Air Force are now addressing these issues associated with the development of thin-film arrays for space. Copper indium gallium diselenide (CIGS), cadmium telluride (CdTe), and amorphous silicon (a-Si) thin-film materials appear to have a good chance of meeting several proposed space power requirements [38]. Reasonably efficient (~8% AM1.5) large area flexible blankets using a-Si triple junction technology are already being manufactured.

Table 10.6 summarizes the thin-film solar cell technologies that are currently available. Further details on a-Si, CIGS, and CdTe solar cells can be found in Chapters 12–14, respectively. Several device structures offer specific power exceeding 1000 W/kg, but these values only include the device and substrate not the entire module and array. This table shows the importance of lighter or thinner substrates in achieving higher specific power. Note that multijunction cells (like the a-Si triple cells) whose thicknesses and bandgaps have been optimized for the terrestrial AM1.5 spectra should be re-optimized for AM0 since the distribution of photons between top, middle and bottom cells will be different. This changes the current matching. Reoptimization is not required for single junction thin-film devices. References 39 and 40 showed no substrate dependence for a-Si devices; that is, the same efficiency resulted between deposition on thin (10–25 μm) or thick (125 μm) stainless steel or between stainless steel or Kapton. This is good news for obtaining lighter thin film modules with higher specific power. In contrast, efficiency of Cu(InGa)S devices decreased from 10.4% to 4.1% as the stainless steel substrate decreased in thickness from 128 μm to 20 μm [44]. An 11% efficiency for CdTe on 10 μm polyimide was reported but is unpublished [45].

Development of other wide bandgap thin-film materials to be used in conjunction with CIGS to produce a dual-junction device is underway. As has already been demonstrated in III-V cells for space use, a substantial increase over a single-junction device