



Summary

This report provides an extensive overview and assessment of the state-of-the-art (SoA) for small spacecraft technologies publicly available as of April 2026. The reader should be aware that the pace of SmallSat technology advancement overall is rapidly accelerating and varies per subsystem chapter. Recent developments in small satellite technologies reflect a broader shift from experimental, low-cost platforms toward highly capable, mission-flexible systems that can operate across increasingly demanding environments. Advances in materials science, power systems, avionics, and communications are collectively enabling this transition, while market dynamics are pushing both emerging startups and established players to differentiate through cost efficiency, performance, and service-based models.

One of the most critical enabling areas is energy storage and power management. Ongoing research into solid electrolyte materials is driving the next generation of batteries, offering improved safety, energy density, and thermal stability compared to traditional lithium-ion designs. These advances are particularly important for CubeSats and other small spacecraft, where tight volume and mass constraints demand highly efficient energy solutions. At the same time, improvements in maximum power point tracking (MPPT) algorithms are allowing satellites to extract more usable energy from solar arrays under varying orbital conditions. Coupled with this is a growing emphasis on thermal management: as silicon-based power devices approach their operating temperature limits, advanced cooling solutions and materials with enhanced thermal conductivity are becoming essential to maintain performance and reliability.

Thermal and power challenges are closely linked to the increasing computational and operational demands placed on small satellites. A major trend in spacecraft technology is the push toward high-performance avionics capable of supporting autonomy, edge processing, and machine learning. These capabilities are particularly valuable for missions in dynamic or remote environments, where real-time decision-making reduces reliance on ground control. As Earth observation missions, for example, generate ever larger volumes of data, onboard processing helps mitigate constraints in downlink bandwidth and power availability for high-rate transmissions. Edge computing thus becomes not just an enhancement, but a necessity for maintaining mission efficiency.

Communications technology is also evolving rapidly. Optical communication systems, once considered impractical for small spacecraft, are now becoming feasible for microsatellite missions. These systems offer significantly higher data rates compared to traditional radio frequency links, helping address the growing bottleneck in data transmission. However, regulatory constraints—such as limits on power flux density set by bodies like the ITU and NTIA—continue to shape system design, requiring careful balancing of transmission power, bandwidth, and interference considerations.

Another notable shift is in platform design and mission architecture. Traditional CubeSat constellations are increasingly being replaced or supplemented by more capable clusters of spacecraft and larger small-satellite platforms. The acceptable mass threshold for minisatellites and small satellites has expanded, reflecting demand for systems that can carry more sophisticated payloads and support longer, more complex missions. This trend is evident in both commercial and government sectors, where customers are seeking platforms with greater autonomy and versatility, including the ability to operate beyond low Earth orbit (LEO). Indeed, small satellites are no longer confined to LEO science missions; they are emerging as viable candidates for deep-space exploration and lunar applications, as demonstrated by initiatives like NASA's Commercial Lunar Payload Services (CLPS) program [1], which aims to deliver scientific instruments to the Moon at reduced cost.



The evolving ecosystem is also reshaping the satellite supply chain and business models. The integration of hardware components—such as satellite buses and deployment systems—has become increasingly interconnected, with growth in one segment driving expansion in the other. At the same time, startups are introducing innovative service-based approaches. For example, some companies offer power control and distribution unit (PCDU) functionality as a service, charging customers based on mission duration or power usage rather than requiring upfront hardware investment. This reflects a broader trend toward modularity and commercialization, making advanced capabilities more accessible to a wider range of operators.

Finally, industry dynamics reveal a divergence in strategic priorities. Emerging companies tend to focus on cost reduction, scalability, and localization of production, aiming to capture market share through affordability and flexibility. In contrast, established players emphasize performance, reliability, and heritage, catering to high-stakes missions where risk tolerance is low. Despite these differences, both segments are responding to the same overarching demand: a need for more capable, adaptable small satellite platforms that can support increasingly complex and data-intensive missions.

In summary, small satellite technologies are undergoing a significant transformation driven by advances in materials, power systems, avionics, and communications, alongside evolving market demands. These developments are enabling a new class of spacecraft that bridge the gap between traditional CubeSats and larger satellites, opening the door to more ambitious missions in Earth orbit and beyond.

This report will be updated annually as emerging technologies mature and become state of the art. Any current technologies that were inadvertently overlooked in this version may be included in subsequent editions. Updates to technologies listed in this report could be also modified in subsequent revisions. This report is also available online at: <https://www.nasa.gov/smallsat-institute/sst-soa>. Technology inputs, updates, or corrections can be made by reaching out to the editor of this report at arc-sst-soa@mail.nasa.gov.

References

- (1) NASA, “Commercial Lunar Payload Services.” 2026, [Online] Available at: <https://www.nasa.gov/commercial-lunar-payload-services/>.