The analytical testing of cell-based products presents unique challenges in comparison to small molecule or traditional biological drugs. Many cell therapy assays are novel, technically complex, time and labor intensive. Patient-specific manufacturing magnifies these problems since it requires assays to be executed more frequently. Automation is one potential solution, as it offers the possibility of increasing assay speed and quality (e.g. accuracy, reproducibility and repeatability) while reducing operator error, labor and assay cost. Currently, there are no off-the-shelf automation solutions for cell therapy methods. A fully automated assay may be attractive because it significantly reduces the demand on labor and can ease transfer of a method to different QC labs. Establishing an fully automated system, however, can be expensive, time consuming and requires specialized expertise. For these reasons it may make sense to automate only the portions of an assay that are costly or represent significant bottlenecks. Presently, we outline a path for establishing a modular automated assay. Considerations when selecting the best platform included barcoding, liquid handling, robotics, data analysis and integrity. Suitability and performance criteria were established for each of these components. Four flow cytometry platforms were tested in the lab, evaluated against these criteria, and a single instrument was selected for further development. As a proof-of-concept, an existing manual phenotyping method was transferred to the automated system. The new assay significantly outperformed the historical method based on cost, labor and ease of use. The assay could be further improved through refinement and by introducing additional automation.