Mark Hilburger (00:15):

Hello. My name is Mark Hilburger. I'm principal technologist for structures and materials within STMD. And today I'll be presenting to you our strategic technology plan for advanced materials, structures and manufacturing.

Mark Hilburger (00:30):

STMD has put together a strategic framework to help articulate their mission and objectives. And the guiding principles are to provide technology investments that ensure American global leadership in space technology. This includes four main areas, including lunar exploration building to Mars, robust national space technology engine to meet national needs, US economic growth for space industry and to expand commercial enterprise in space.

Mark Hilburger (01:02):

There are four main thrust areas to achieve these goals. Those are included there in the center of this slide. They include Go, Land, Live, and Explore. There are 13 technology capability areas that support these thrust areas, and advanced materials, structures, and manufacturing is one of those 13 areas.

Mark Hilburger (01:24):

While advanced materials, structures, and manufacturing are captured under the Live thrust area, it actually is one of many cross cutting capabilities and has impact in all four thrust areas. The strategic framework also includes high-level strategic outcomes. Advanced materials, structures, and manufacturing provides technology to most of the outcomes in one shape or form. Areas of major emphasis are highlighted here, including enabling surface habitats that utilize local construction resources as well as lightweight structures for launch vehicles, high-temperature materials for propulsion systems, and many other exciting areas.

Mark Hilburger (02:07):

So let me talk a little bit about the advanced materials, structures, and manufacturing strategic technology plan. In order to achieve the goals that I just talked about, STMD is developing a series of strategic technology plans for each of those capability areas. In this slide and the next slide, I'll provide a description of our advanced materials, structures, and manufacturing, or AMSM, strategic technology plan, or STP. I'll also provide you scope and what is defined within the STP. As one might imagine, the scope of this work is extremely broad.

Mark Hilburger (02:46):

So first off, the AMSM STP describes advanced materials, structures, and manufacturing technologies used in the design, development, manufacture, construction, and certification of spaceflight exploration systems. The AMSM technologies include applications to crewed and uncrewed launch vehicles, in-space transportation, landers, surface infrastructure and construction, satellites, science platforms and commercial space systems. Within these systems are many subsystems and include things like advanced propulsion, cryogenic fluid management, entry, descent, and landing, in situ resource utilization, flight support and habitat systems and power generation.

Mark Hilburger (03:31):

We're developing our plan in an integrated manner with help from our NASA centers, mission directorates, other government agencies, industries, academia and international partners. AMSM technology advancement is never finished. It requires support across all the technology pipeline, and leverage all current research activities. As I mentioned earlier, the scope of AMSM technologies is quite significant. It includes 16 different technology categories and 63 subcategories across our domain.

Mark Hilburger (04:05):

So now very briefly, I talk about these AMSM taxonomies and these 16 areas are highlight. There are six areas within the materials discipline, including lightweight structural materials, computational materials, flexible materials, materials for extreme environments, materials with specialized functions, materials for advanced manufacturing and construction. And underneath these six areas are 26 subcategories.

Mark Hilburger (04:34):

Structures area includes five main topics including lightweight concepts, design, analysis and certification methods, reliability and sustainment, innovative multifunctional concepts, and mechanical systems. They also include 20 subcategories below them.

Mark Hilburger (04:52):

Manufacturing, the final area, includes five topic areas: advanced manufacturing, digital model-based manufacturing, nondestructive evaluation, sustainable manufacturing, and excavation and surface construction. Within these five areas, there are 17 subcategories of technology topics. So again, a very broad and incredibly diverse set of technology needs to enable massive exploration missions.

Mark Hilburger (05:26):

Now I'd like to describe to you a few of the sections of our strategic technology plan and how we are going to articulate the specific technology needs in order to meet our exploration missions and capability-specific outcomes. First off, section one is a description of the advanced materials, structures, and manufacturing capability, and describe to you in more detail the scope of the technology areas and specific technology needs. It also describes the architecture applicability, capability-specific outcomes.

Mark Hilburger (06:04):

Once AMSM is fully described in section one, specific technology gaps are listed in section two. These gaps include the following information: first an overview of each of the gaps, and then a current state-of-the-art assessment, minimum acceptable performance metrics for key performance parameters, and then a gap closure plan, some idea of how we feel we will be able to achieve closure on these gaps, and finally an indication of what platforms or elements will be enabled or enhanced when we do achieve these gaps. Through the process, each gap is going to be clearly linked to a specific priority outcome that comes earlier in the document. It'll include a clear definition of why the gap is important and how the gap will be closed.

Mark Hilburger (06:57):

The final section here, section three will include push technologies. These technologies don't necessarily have an immediate architectural application, but it may be one that appears highly promising in meeting future technology needs. We still believe that there is a strong need for basic fundamental research and low TRL work for future advancements.

Mark Hilburger (07:21):

Now I'd like to present a snapshot of several of our 32 priority AMSM gaps. I just picked three across several different disciplines. The first gap is on high-temperature composite materials, which are required to have reduced property variability and increased strength. This gap also includes a quick description of what is needed and why this gap is important. And for this particular gap, we were looking to find advanced carbon/carbon materials for high-temperature applications. It was one of the materials of choice for use on the X-37 control surfaces and the Solar Probe heat shield and many other Department of Defense applications.

Mark Hilburger (08:03):

The advanced carbon/carbon was evaluated for an ablative heatshield for Earth reentry of the Mars Sample Return capsule, but it was rejected primarily due to low interlaminar properties. These materials also showed a lot of material property scatter due to manufacturing variabilities. Thus, the gap is asking for extreme temperature composites with process modeling capability needed to provide an understanding of the relationship between chemistry during manufacturing and the final material performance, thus reducing property variability and increasing strength.

Mark Hilburger (08:42):

Another gap, gap number 26, is associated with construction of landing pads, habitats, shelters, roadways, berms and blast shields using lunar regolith on the moon. Surface construction on the moon is really an incredibly important topic. It's needed to sustain human presence on the moon for future generations. Surface construction technologies needed using locally-derived as well as Earth-derived materials, both horizontal construction, being roads and landing pads, as well as vertical construction such as foundations and blast shields, pressurized habitats. But we need many, many additional advancements in technologies to mature technologies needed to meet this gap need.

Mark Hilburger (09:40):

And finally, additive manufacturing of large-scale propulsion system components is another gap that we are carrying along here. This gap includes technology developments and advances for large-scale, lightweight, multi-metallic freeform manufacturing as well as composite overwrap technologies and analysis capabilities. While additive manufacturing technologies are transforming component fabrication, there still are some very large challenges associated with developing and certifying large-scale additive manufacturing structures. For example, long-duration builds for very large structures, such as the one shown in this picture here, can result in build failures associated with material distortion and residual stresses. These are a significant concern. Those are just three of the 32 high-priority gaps that we have within the advanced materials, structures, and manufacturing capability.

Mark Hilburger (10:45):

And finally, I want to close by talking about some of the recent SBIR and STTR-related activities that support the AMSM capability. In fiscal year '20, SBIR and STTR had around 25 topic areas that included 60 awards to small businesses. So there's a lot of opportunity for collaboration with small business, and they have supported many of our projects, big and small.

Mark Hilburger (11:12):

Some of the recent larger projects, some of which have ties to or have been supported by small business, include some of the areas and topics included on the right of this slide, including next-generation durability and damage tolerance methodologies; lightweight multi-functional lattice materials; automated reconfigurable mission-adaptive digital assembly systems, which is a fancy way of saying automated structural building or construction; rapid analysis and manufacturing of propulsion technology and so on. So small businesses have played a huge role in developing and maturing technologies for NASA missions.

Mark Hilburger (11:57):

So I encourage you to get up with us, meet with us, and discuss possible opportunities to collaborate with NASA on these exciting missions. Thank you.