Composite Materials for Space and Launch

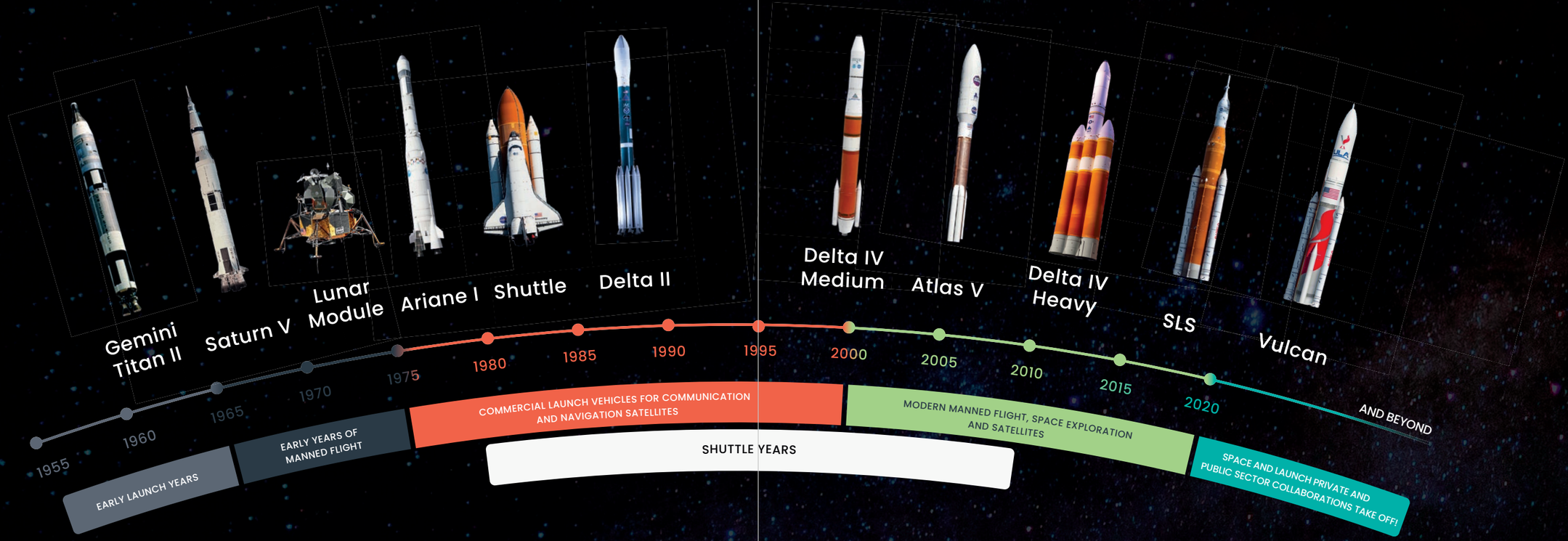
SYENSQO
ADVANCING HUMANITY

Discover High-Performance Solutions for Space and Launch Built on a Legacy of Innovation

Syensqo's innovative materials have been successfully used in space missions from the first moon landing to the recent launch of NASA's Space Launch System (SLS) rocket for the Artemis program. The space and launch industry is rapidly evolving with a weekly cadence of launches to low Earth orbit (LEO) and missions aimed at establishing a sustaining presence on the Moon.

Scan the QR code to watch a video about Syensqo's legacy in space

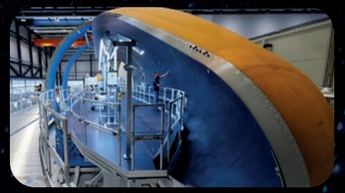
SYENSQO IN SPACE



The demands on materials suitable for space and launch applications are complex. Solutions must simultaneously deliver lightweighting benefits, enable design and processing flexibility, withstand extreme temperatures and maintain reliable performance over time. Syensqo provides the space and launch industry with benchmark materials including CYCOM® and MTM® composites, MX® high-temperature ablatives, FM® adhesives, BR® primers and Torlon® polymers.

Ablatives and High Temp

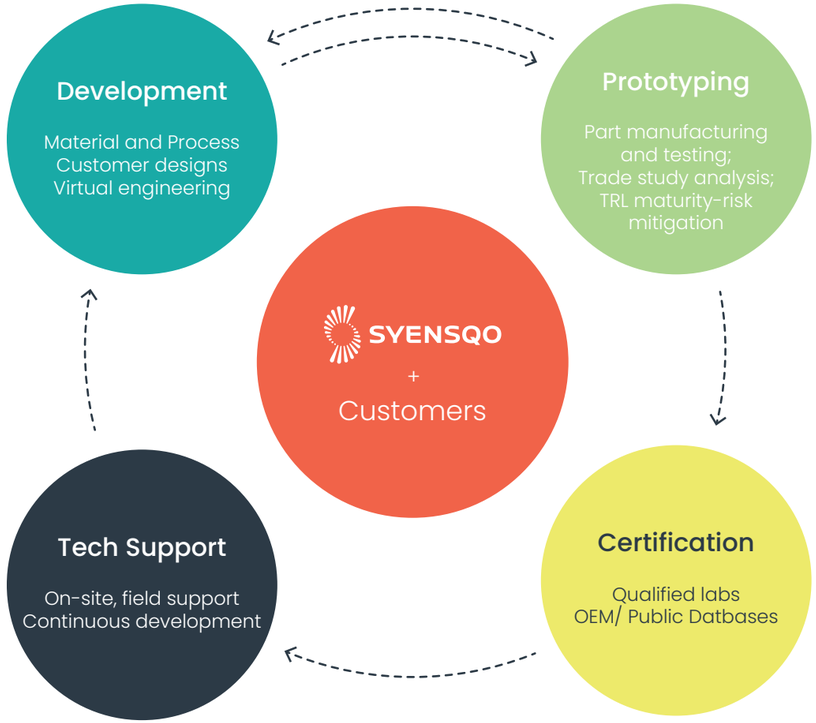
Adhesives and Primers

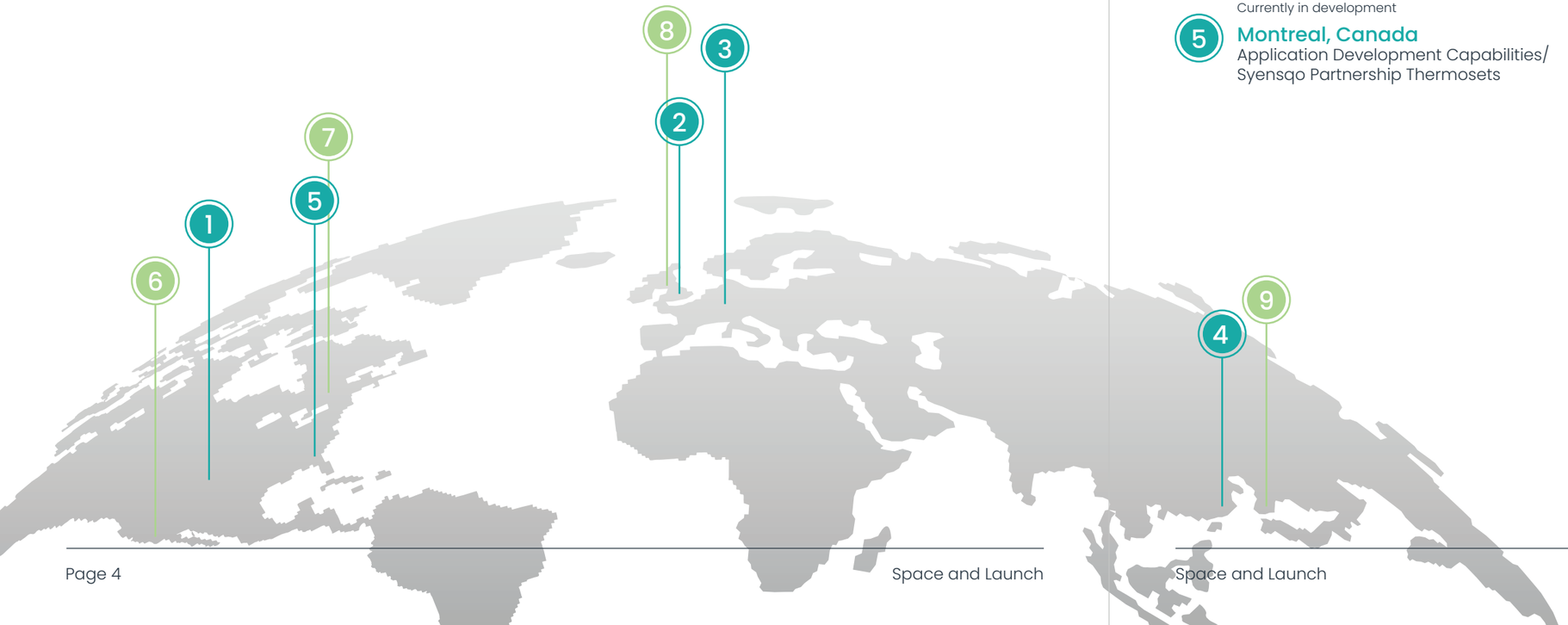


Composite Structures

Pictures credits to: NASA, Ariane, ULA and ESA

Syensqo's Technical Support Model





Global Network of Application and Testing Centers

Syensqo is uniquely positioned thanks to our ability to support customer projects within our global network of application and testing centers. Our state of the art facilities have the equipment, software and expert staff to support testing, simulation, processing and prototyping.

Our application centers are where we innovate with our customers by providing a space to collaborate and explore the art of what's possible. It is the place where the integration of design, materials and processes comes to life. Within our centers customers can develop their concepts and de-risk their solutions, gaining the confidence to reproduce the same optimal results in their own facilities.

Our testing centers are fully equipped to meet the rigorous needs associated with aerospace qualifications and our experienced teams ensure your testing and qualification campaigns are executed on time and to the highest standard as expected by the aviation industry and authorities.

Application Centers

1. **Wichita, KS USA**
   Thermoset & Thermoplastic Composite Manufacturing Innovation Center within NIAR ATLAS
2. **Heanor, UK**
   Thermoset Composite Application Center
3. **Brussels, Belgium**
   Thermoplastic Composite Application Center
4. **Shangai, China**
   Thermoset & Thermoplastic Composite Application Center
   Currently in development
5. **Montreal, Canada**
   Application Development Capabilities/ Syensqo Partnership Thermosets

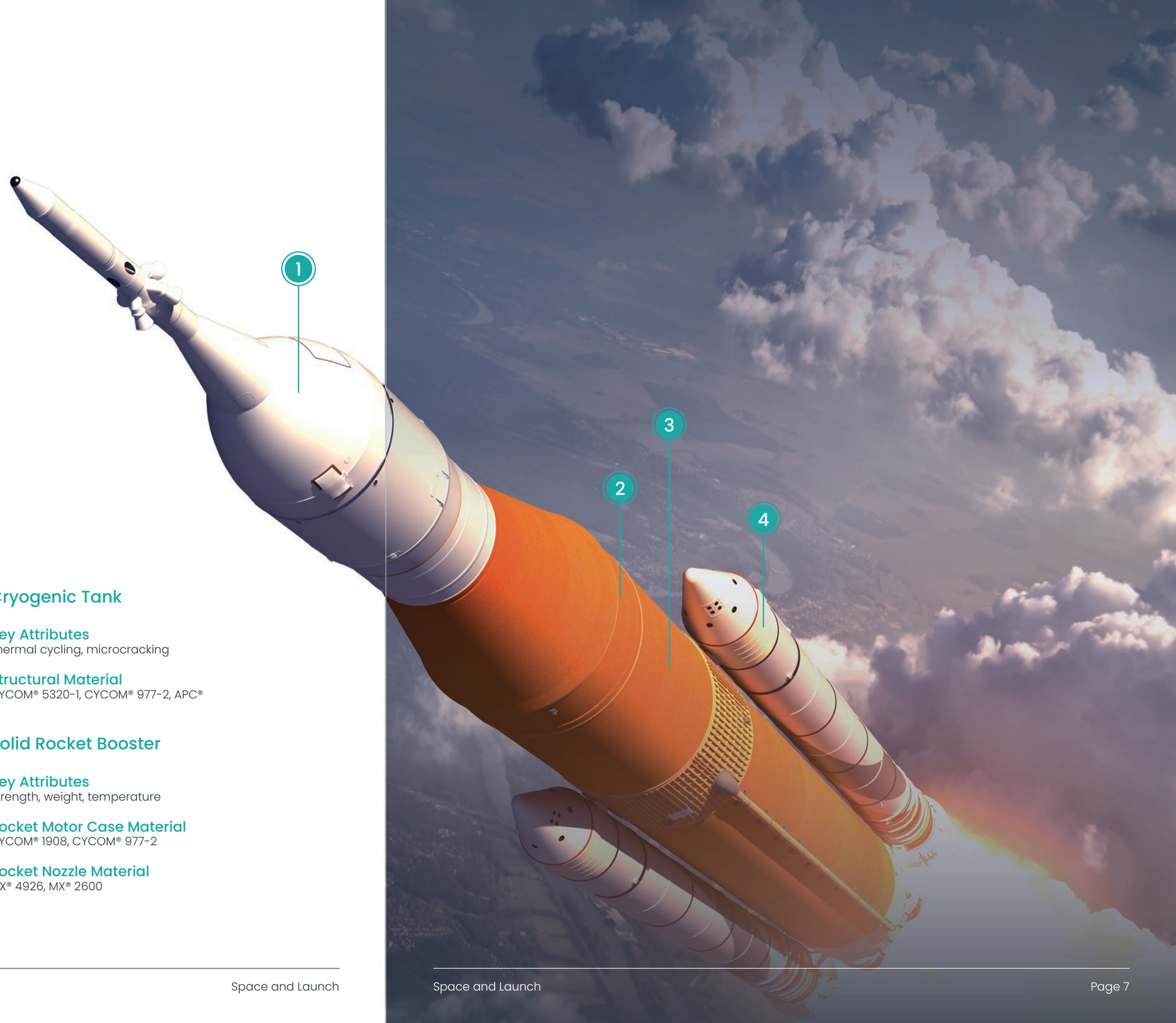
Testing Centers

6. **Anaheim, CA USA**
   Qualification Test Lab
7. **Alpharetta, GA USA**
   Thermoplastic Applications Lab
8. **Wrexham, UK**
   Qualification Test Lab
9. **Seoul, South Korea**
   Auto R&I Center

Launch Vehicles

Whether customers are launching a constellation of satellites to LEO, deploying spacecraft like the James Webb Telescope, or performing critical defense missions, the different classes of launch vehicles all require materials that are lightweight and guarantee peak performance in the harshest of environments.

Syensqo's solutions for launch vehicles deliver reliable, best-in-class performance properties while also enabling processing flexibility for optimizing manufacturing operations on Earth.



1 Payload Fairing

Key Attributes
Strength, weight, OOA processing flexibility

Structural Material
MTM® 46, MTM® 45-1, CYCOM® 5320-1

2 Primary Structures

Key Attributes
Strength, weight, manufacturability

Structural Material
EP® 2190, MTM® 45-1, CYCOM® 5320-1

3 Cryogenic Tank

Key Attributes
Thermal cycling, microcracking

Structural Material
CYCOM® 5320-1, CYCOM® 977-2, APC®

4 Solid Rocket Booster

Key Attributes
Strength, weight, temperature

Rocket Motor Case Material
CYCOM® 1908, CYCOM® 977-2

Rocket Nozzle Material
MX® 4926, MX® 2600

Space and Satellite

The space race has changed since its early days in the mid-twentieth century, with many new private companies and governments attempting to deploy their own spacecraft for Earth observation (EO) and deep space exploration.

The focus in the space manufacturing sector continues to shift more toward lightweighting and structural integrity to support long-term use and performance. Since these optimizations have become a priority, materials that enable resistance in harsh environments and improve mechanical performance are critical for the structural components on the next generation of lunar landers, rovers and probes.

1 Spacecraft

Key Attributes
Strength, weight, temperature

Structural Material
CYCOM® 5250-4

2 Crew Modules

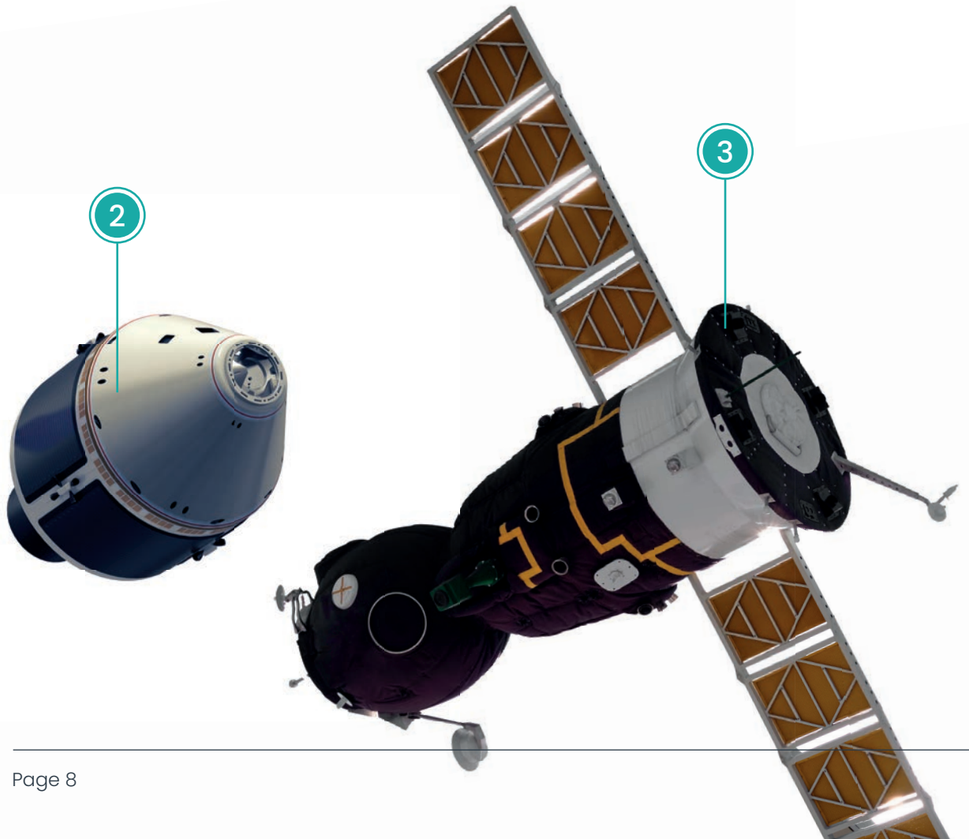
Key Attributes
Strength, weight, outgassing

Structural Material
CYCOM® 977-2

3 Satellites

Key Attributes
Strength, weight, outgassing

Structural Material
CYCOM® 950-1



Adhesives and Surface Preparation - Applicable to Spacecraft, Crew Modules and Satellites

Film Adhesive: FM® 300, FM® 309-1

Core Splice: FM® 410-1

Surface Prep: FusePly®

Primer: BR® 127

Syensqo has an extensive range of ablative products suitable for the Space and Launch market. The items below represent a portion of our portfolio.

Product Family	Product Name	Application	Key Attributes	Cure / Consolidation Process: Autoclave	Cure / Consolidation Process: Compression Mold	Reinforcement: Carbon	Reinforcement: Silica	Reinforcement: Glass	Product Forms: Broad Goods	Product Forms: Bias Tape	Product Forms: Molding Compound
Ablatives	MX 4926	Nozzle, Exit Cones	• Widely used material with large database • Industry standard for use in small and large nozzles for rocket motors • Best erosion performance of the available molding compounds as rayon-based carbon fabric impregnated with a modified phenolic resin ideal for high-heat applications like rocket nozzle materials and motors, exit cones and overwraps	●	●	●			●	●	●
	MX 2600	Nozzle, Insulators, Exit Cones	• Widely used material with large database • Works well in oxidative environments • Silica fabric impregnated with phenolic resin containing silica filler	●			●		●	●	●
	MX 2646	Nozzle Insulators, Igniters	• Toughened phenolic system • Silica reinforced product with broad goods and molding compound product forms		●		●		●		●
	MXB 360	Launch Canister Liner, Blast Deflectors	• Glass matte fiber reinforced phenolic system • Good erosion properties suitable for gas management systems	●	●			●	●	●	
	MXB 6001	Overwraps for Nozzle, Exit Cone	• High mechanical performance • Glass phenolic fabric widely used for overwrap applications	●				●	●	●	
	FM 5504	Nozzle, Insulators, Exit Cones	• Widely used material with large database • Preferred silica reinforced product for thick cross section parts • Useful in intermediate-temperature ablative applications where oxidation potential is high	●			●		●	●	

* Ablative products are capable of meeting MIL-R_9299

Product Family	Product Name	Application	Key Attributes	Temperature Performance	Cure / Consolidation Process			Reinforcement				Product Forms			Design Data
Syensqo has an extensive range of composite products suitable for the Space and Launch market. The items below represent a portion of our portfolio.															
				Dry Tg^2 / Wet Tg^2	VBO	Autoclave	Press	IM CF	SM CF	E-GF	Other	Fabric	UD Tape	AFP/ATL	
Structural Composites	CYCOM® EP2190	Launch Vehicle Structures	• Highly toughened epoxy system with excellent impact and fatigue resistance • Optimal for AFP use in launch primary structures and stage adaptors	185°C / 142°C		●		●	●		S2 Glass	●	●	●	NCAMP[2]
	CYCOM® 977-2	Launch Vehicle and Space Structures, Cryogenic Tanks	• Versatile epoxy system with pedigree as industry standard for Space and Launch • Optimal for use in wide range of structural Space and Launch applications	170°C / 135°C		●		●	●		HM Carbon	●	●	●	Syensqo / Low Outgassing
	CYCOM® 5320-1	Launch Vehicle Structures, Cryogenic Tanks	• Exceptional epoxy system hot/wet performance and with flexible process capability • Optimal for large structures: payload fairing and cryogenic tank applications	195°C / 163°C	●	●		●	●			●	●	●	NCAMP
	CYCOM® 1908	Rocket Motor Case	• Epoxy towpreg compatible with oven or autoclave curing procedures • Optimal for manufacturing of thick wall composites and rocket motor case winding	193°C / -	●	●		●							Syensqo
	CYCOM® 950-1	Satellite Structures	• Low outgassing epoxy system and available on HM fiber for space applications • Well suited for use in satellite structure applications	180°C / 140°C	●	●			●		HM Carbon	●	●	●	Syensqo / Low Outgassing
	CYCOM® 5250-4	Spacecraft Structures, Heat Shields	• Aerospace and Defense industry standard bismaleimide resin systems • Ideal for high temperature spacecraft applications	271°C/ 207°C		●		●				●	●	●	Syensqo
	MTM® 45-1	Launch Vehicle Structures	• Epoxy systems with wide process window and cure temperature flexibility • Well suited for aft skirt structure and interstage rings for launch vehicles	180°C / 160°C	●	●	●	●	●	●	S2 Glass Quartz	●	●	●	NCAMP/ Outgassing
	MTM® 46	Payload Fairing	• Epoxy system with relatively fast curing capability • Well suited for large out of autoclave fairing structures	190°C / 130°C	●	●	●	●[1]	●	●		●	●	●	Syensqo / Low Outgassing

[1] Based on onset Tg per DMA
[2] In process

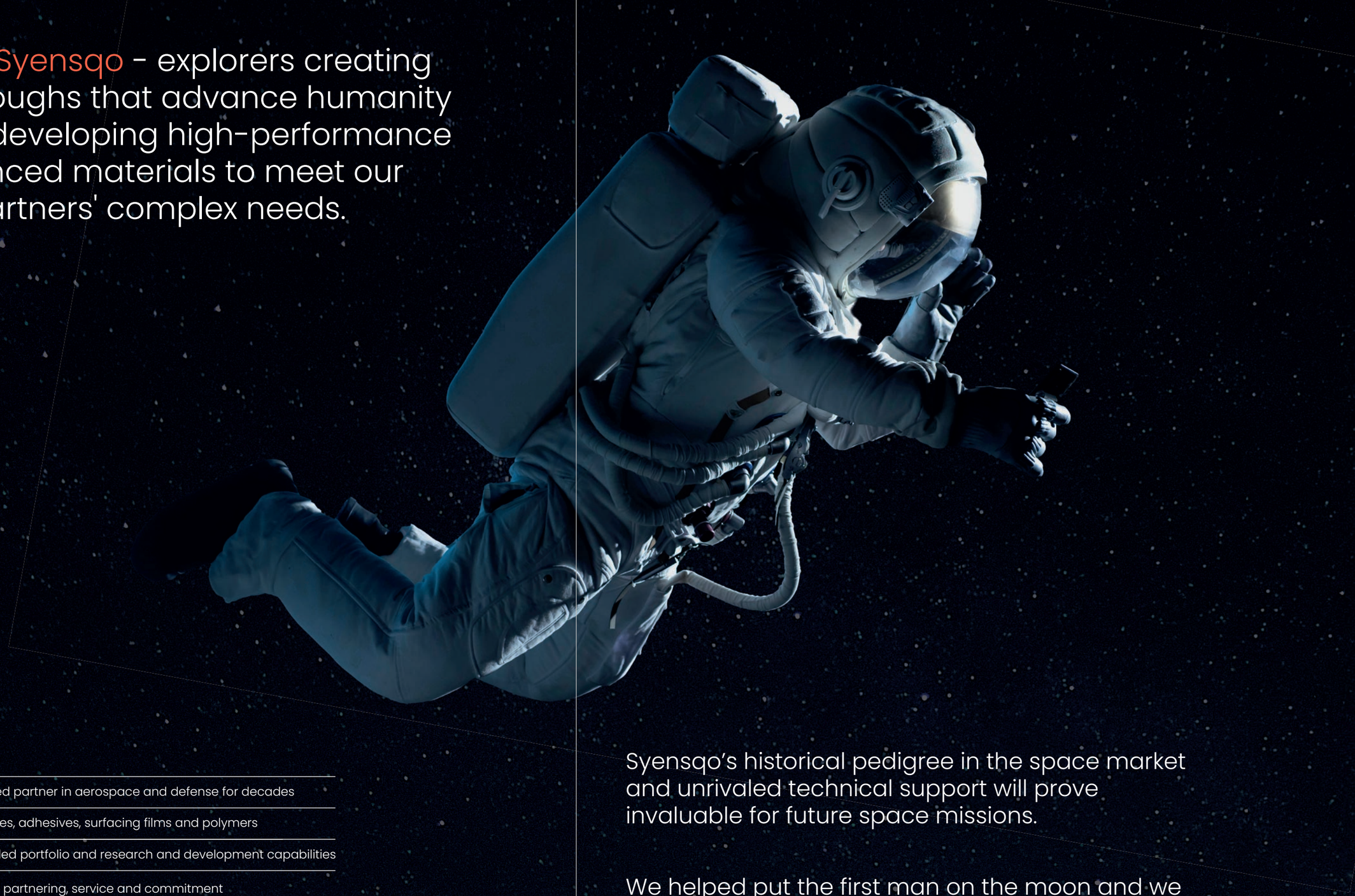
Product Family	Product Name	Key Attributes
Syensqo has an extensive range of ablative products suitable for the Space and Launch market. The items below represent a portion of our portfolio.		
Film Adhesive	FM® 73	• A modified epoxy with a unique combination of high temperature performance, toughness and moisture resistance as demonstrated by retention of shear properties after pre-bond humidity exposure • Designed for bonding metallic and composite structures with a 104°C service temperature • Outgassing TWL, CVCM tested to NASA standards
	FM® 300	• A strong epoxy adhesive designed to bond metal-to-metal and composite structures • When combined with other Syensqo materials, it is ideal for creating environmental resistance in space and satellite structures. • Outgassing TWL, CVCM tested to NASA standards
	FM® 300-2	• A 180°C curing version of FM® 300 • When combined with other Syensqo materials, it is ideal for creating environmental resistance in space and satellite structures • Outgassing TWL, CVCM tested to NASA standards
	FM® 309-1	• Next generation epoxy system with a combination of high Tg, high toughness, and high temperature shear properties • Suitable for monolithic and honeycomb bonding applications with service temperature up to 180°C dry, 140°C wet
Peel Ply	FusePly®	• Breakthrough composite bonding technology that enables a consistent, predictable, and quantifiable bonding surface • Allows for chemically bonded structures in co-bond and secondary bonding processes • Systems compatible with 120°C and 180°C prepregs and adhesive films
Primer	BR® 127	• The industry standard for high-performance corrosion inhibiting primers and has been used in virtually every aerospace program since its introduction • Outgassing TWL, CVCM tested to NASA standards
Paste	Aeropaste®	• 1 or 2 part product range that can be cured from room temperature up to 180°C • High strength, high toughness, excellent hot/wet performance with a flexible, low temperature cure cycle
Core Splice	FM® 410-1	• A modified epoxy adhesive foam containing no metallic fillers • Designed for honeycomb splicing under ambient pressure and ideal for bonding large skins on fairing or launch vehicle structures • Outgassing TWL, CVCM tested to NASA standards

Syensqo has an extensive range of composite products suitable for the Space and Launch market. The items below represent a portion of our portfolio.

Product Family	Product Name	Application	Key Attributes	Temperature Performance	Cure / Consolidation Process			Reinforcement					Product Forms			Design Data
				Dry Tg^2 / Wet Tg^2	VBO	Autoclave	Press	Injection Molding	IM CF	SM CF	E-GF	Other	Fabric	UD Tape	AFP/ATL	
Thermoplastics	APC PEKK FC	Launch Vehicle Structures	• High toughness and damage tolerance • Good resistance to a wide range of fluid environments • Outstanding FST and OSU heat release properties • Low moisture uptake (<0.3 % by wt.)	160°C / 155°C	●	●	●		●[1]	●			●	●	●	Syensqo
	APC-2 (PEEK)	Launch Vehicle Structures	• Very high toughness, damage tolerance, and good wear resistance • Excellent environmental resistance • Good resistance to creep and fatigue • Outstanding fire resistance	145°C /140°C	●	●	●		●	●		S2 Glass		●	●	Syensqo
	Torlon® PAI	Rocket Engines	• Best-in-class friction and wear performance • Excellent strength and toughness • Inherent flame resistance	265°C				●		●	●					Syensqo

[1] Developmental Product
[2] Based on onset Tg per DMA

We are Syensqo - explorers creating breakthroughs that advance humanity through developing high-performance advanced materials to meet our partners' complex needs.



Summary

Heritage	Recognized partner in aerospace and defense for decades
Portfolio	Composites, adhesives, surfacing films and polymers
Technology	Unparalleled portfolio and research and development capabilities
Reputation	Known for partnering, service and commitment throughout the program life-cycle; from concept to production
Responsibility	We commit and supply for the long haul

Syensqo's historical pedigree in the space market and unrivaled technical support will prove invaluable for future space missions.

We helped put the first man on the moon and we are well-positioned to play a leading role in future space colonization.

SYENSQO

www.syensqo.com