Thermoplastic Composites Conference

Thermoplastics Development for Exploration Applications (TDEA) Project

Programmatic and Technical Overview

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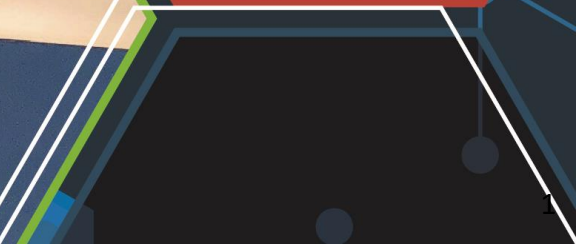


ACMA American Composites Manufacturers Association

Thermoplastic Development for Exploration Applications (TDEA) Project Overview

Goal:

Advance NASA's thermoplastic composites capabilities by developing structurally efficient joining solutions for large-scale space structures and applications to support NASA's future exploration missions.

Objectives:

1. Assess the current capability for design, analysis, and manufacture of commercially available thermoplastic material systems for large-scale space structures and on-orbit applications.
2. Evaluate thermoplastic composite material systems for large-scale space structures and on-orbit applications.
3. Develop NASA's in-house capabilities in the area of thermoplastic composites processing and manufacturing.
4. Develop and understand advanced thermoplastic joining technique(s) relevant to space environments and applicable to unitized and/or reconfigurable composite structures.
5. Advance structural analysis capabilities for the design and analysis including failure prediction of thermoplastic composites including joints.

Team:

MSFC (lead),
GSFC,
GRC,
LaRC

Budget:

$10.5M, FY22-24

Game Changing Development Program

Why Thermoplastic Composites?

Qualitative comparison of thermoplastic composites (TPC) and thermoset composites (TSC)

Advantages:

- Reduced cycle time
- **Processing by remelting**
- Automated assembly (robotic welding)
- **Higher fracture toughness**
- **Ambient storage, no shelf life**
- **Welded joints with no material interface**
- **Processing that enables unitization**
- **Minimal outgassing**
- Low moisture uptake

Disadvantages:

- **Higher processing temperature and pressure required**
- **Higher residual stresses (more difficult dimensional control)**
- Higher raw material cost
- Structural and chemical properties sensitive to crystallinity
- Higher melted viscosity
- Crystallinity may change over lifecycle
- Lower TRL

Bolded characteristics especially relevant for space applications

Selected property comparison

Property	TPC T700/LM PAEK[b]	TSC IM7/8552[a]
Density, ρ	1.6 g/cm3	1.6 g/cm3
Glass transition temperature[c], T_g	147°C	200°C
Transverse stiffness, E_{22}	9.1 GPa	8.7 GPa
Transverse tensile strength[d], Y_T	94 MPa	80 MPa
Interlaminar toughness, G_{1c}	2.1 kJ/m^2	0.24

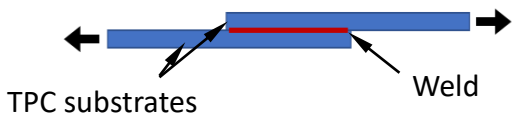
[a]Wanthal, et al., ASC Conference, 2017
[b]NCAMP database, report CAM-RP-2019-036 RevA
[c]Neat resin, dry, from manufacturer's datasheet
[d]ASTM D3039

Recommendations: High Priority TPC Developments for Space Applications

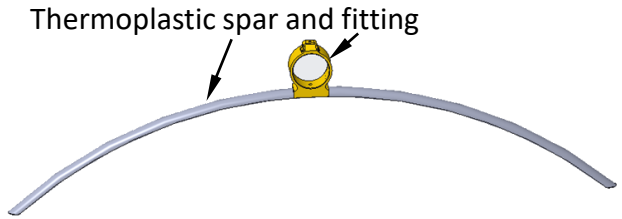
	Recommendation	Objectives	TDEA Contribution
1	Launch vehicle structure trade study: TSC vs. TPC	• Quantify the weight and costs savings for TPC compared to SoA TSC baseline. • Characterize the applicability of TPCs for launch vehicle cryotanks.	Preliminary assessment of weight savings with postbuckled TPC design.
2	TPC material qual. for space applications	• Generate space-relevant material properties for candidate TPC materials to support future trade studies and PDR level analysis.	Laminate mechanical performance: AS4/PEEK, AS4/PPS, T700/LM PAEK, AS4/PEI (additional mat'ls and tests TDB)
3	Demonstrate capability for TPC welded joints (flat coupons)	• Confidence in TPC welded joint design, sizing, and fabrication at the coupon scale. • Analysis tools and relevant experience to assess welding methods for terrestrial and in-space assembly (ISA). • Characterization of joint behavior in off-nominal environments.	Welded joint pathfinder study
4	Evaluate cost & benefits for low-production-volume TPC parts	• Demonstrate cost-effective materials, process, and structural performance for specialized space application structures (currently made with TSC or metals).	Roman Space Telescope (RST) Deployable Aperture Cover (DAC) 'conceptual' TPC support beam
5	De-risk TPC manufacturing, design, analysis, and inspection technology for in-space construction	• Ground test data for evaluation of ISA with TPCs. • Validated process monitoring and modeling for high-confidence in-space operations. • Tool-less TPC AFP technologies suitable for in-space construction of pressure vessels.	Element/subcomponent test and analysis for ISA using TPCs

TDEA Technology Roadmap

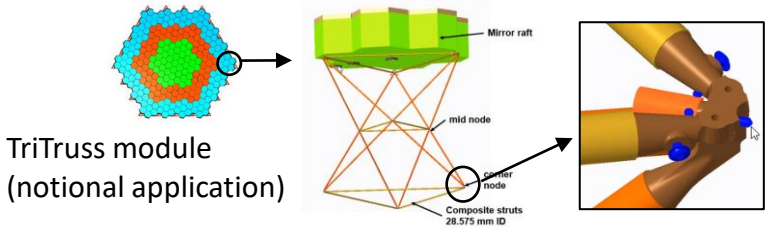
Welded joint pathfinder
Foundational developments



Roman Space Telescope (RST) support beam
Confidence building application



Game Changing application
Developments for in-space TPC truss assembly



What?

- Coupon scale, **single welded interface**
- Develop analysis approaches for welded joints trade studies
- Fabricate and test joints with nominal conditions, and conditions relevant to in-space applications (e.g., off-nominal thermal history, lunar dust contamination)

- Moderate-scale, **single spar and fitting**
- Terrestrially manufactured and assembled spacecraft structure
- Evaluate approaches that reduce cost through reduced part count and complexity compared with the RST baseline design

- Large-scale, **multiple spars and fittings**
- Terrestrially manufacturing and in-space assembly (ISA)
- Identify relevant welded joint design requirements, and establish a TDEA Point Design
- Demonstrate through the building block approach

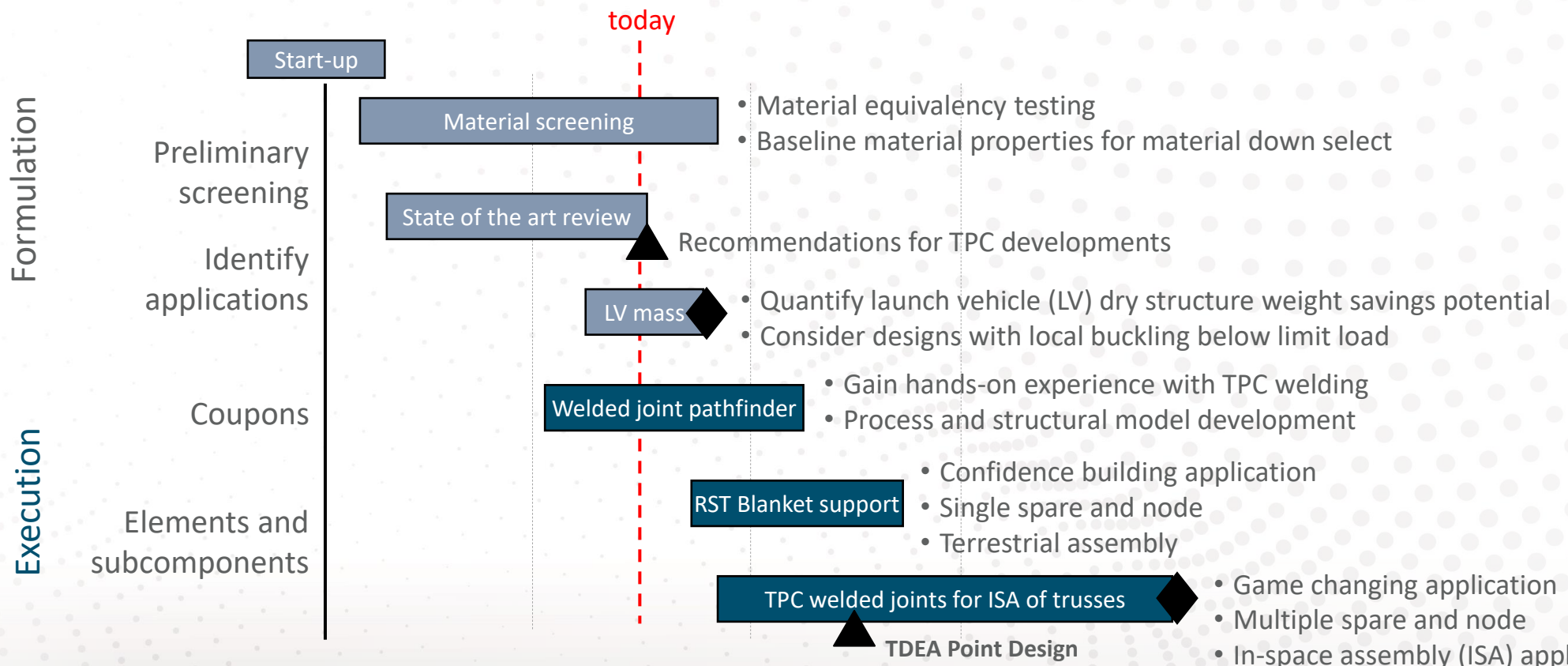
Why?

- Seek in-house capabilities for TPC welding relevant to space applications
- Simple generic configuration to leverage existing data

- Knowledge gap in application of TPCs to low-production-volume applications
- How can processes unique to TPCs (e.g., welding, additive) enable better designs?

- Challenges remain for TPCs use in ISA/OSAM
- Develop deep understanding of considerations for TPC joining in-space

TDEA Planned Activities and Schedule



	FY21	FY22	FY23	FY24
FY21 Budget Request	Worked as part of CTE project	$2M	$3.5M	$5M
Civil servant FTE		9	10	10