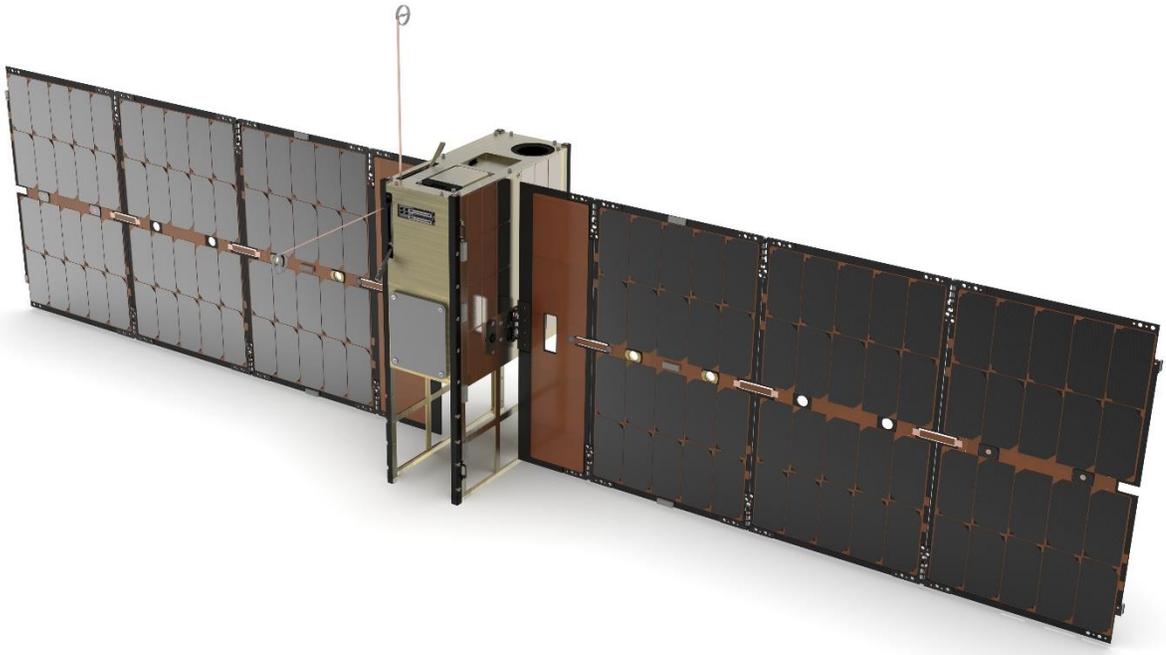




Tyvak

A Terran Orbital Corporation

Trestles 6U/12U Platform Specification Booklet



Tyvak Nano-Satellite Systems, Inc.
15330 Barranca Parkway, Irvine, CA 92618

CAGE Code: 6J8J8; DUNS: 96-947-7814; NAICS: 336414

Executive POC:

Bradley Williams
Director, Civil Space Programs
Bradley.Williams@tyvak.com
949-302-4033

Technical POC:

Allan Shtofenmakher
Mission Formulation Systems Engineer
allan.shtofenmakher@tyvak.com
949-572-8953

Revision B

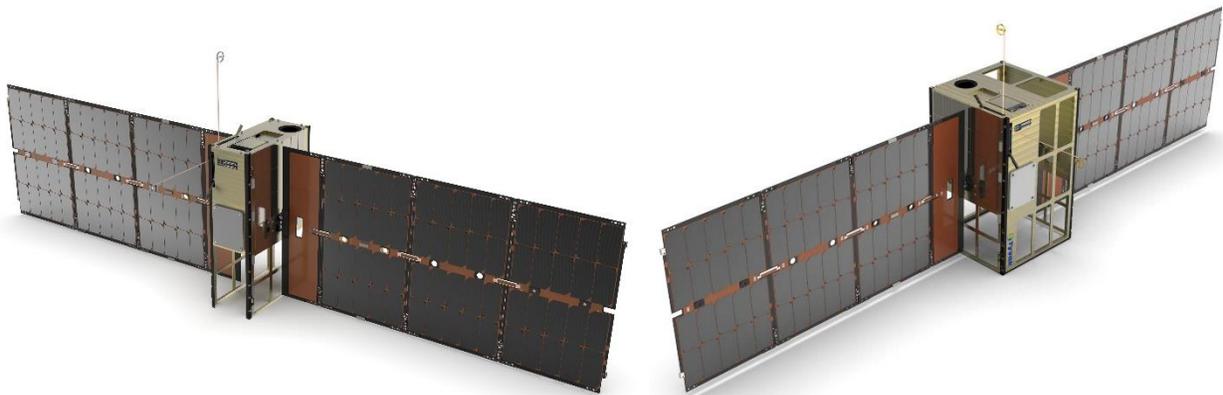
19 January 2021

About Us

Tyvak Nano-Satellite Systems, Inc. (“Tyvak”), a wholly owned subsidiary of Terran Orbital Corporation (“TOC”), was founded in 2013. Tyvak and TOC are U.S. corporations with 100% U.S. ownership. TOC manages a portfolio of business that provides end-to-end small satellite solutions and services. Tyvak is an end-to-end satellite solution provider that designs, integrates, and tests space vehicles and provides deployment and on-orbit services to its customers.

Trusted by civil, defense, and commercial organizations, Tyvak has a proven track record of mission success. As a leader in satellite miniaturization, Tyvak designs and builds custom-architecture spacecraft in the nanosatellite, microsatellite, and minisatellite classes up to 350 kg, providing launch solutions and aerospace technologies for a myriad of defense, intelligence, and scientific programs. Past missions have included autonomous rendezvous, proximity operations and docking, radar systems, science instruments, space situational awareness, technology demonstrations, remote sensing imagers, Earth observation telescopes, and more.

The Trestles 6U & 12U Buses



Trestles 6U Platform

Trestles 12U Platform

Tyvak’s Trestles 6U & 12U buses are the leading nanosatellite platforms for technology demonstration missions and small-scale, low-cost, rapid-turnaround satellite missions of any kind in LEO, GEO, and beyond. The Trestles 6U platform, best known for its role in the success of the NASA Pathfinder Technology Demonstrator program, is designed for payloads roughly 100 mm x 226 mm x 145 mm in size and up to 7.3 kg in mass. The Trestles 12U platform, which is more robust, more customizable, and can support a wider variety of payloads as massive as 15.5 kg, offers the same payload bay as the 6U, as well as an additional, larger payload bay that is roughly 116 mm x 226 mm x 362 mm in size. Spaces that can be occupied by payloads are visible through the gaps in the structure in the two images above.

The Trestles spacecraft are supported by Tyvak’s state-of-the-art MK II nanosatellite avionics platform. The vast majority of MK II modules are developed in house to maximize mission and quality assurance and to minimize schedule risk. The MK II flight computer modules are responsible for spacecraft management and control, provide C&DH, ADCS, and GNC functionality, and support on-board payload data storage. In tandem with COTS antennas, MK II UHF, S-, and X-band radios enable satellite commanding and telemetry. The guidance, navigation, and control software interfaces with a fully redundant, three-axis IMU and multiple star trackers for guaranteed stellar coverage. As a contingency, redundant sun sensors and magnetometers allow for sun-pointing independent of the IMU and star trackers. For actuation, the system uses a family of reaction wheels that depend on vehicle size and agility, along with torque rods for momentum management.

Most avionics modules are common across Tyvak’s 6U, 12U, microsatellite, and minisatellite families of vehicles. This is key to reducing platform prices and ensuring a greater level of mission assurance.

Options & Features

The standard features available for both the Trestles 6U and the Trestles 12U form are tabulated on the next page. Additional options and features can be made available upon discussion with Tyvak. For example, the payload interface boards for both

the 6U and the 12U form factors can be customized to serve the payload’s and the customer’s needs. For the 12U form factor, in particular, an option for fully redundant avionics—including 2 flight computer modules with rad-hard watchdog, an additional S-band radio with dedicated Rx/Tx antennas, an additional IMU, and an additional GPS system—is available for enhancing mission assurance and increasing mission design life to 5 years. Likewise, the Trestles 12U can also support high-data rate X-band radios and antennas and CubeSat-scale propulsion systems. Please contact Tyvak for more information.

With the standard Trestles satellite package, customers can expect Tyvak to handle program management, systems engineering, overall system design, payload integration, and spacecraft AI&T. For customers that prefer to have an end-to-end satellite service experience with a single, highly qualified provider, Tyvak also offers launch integration, mission operation, and ground system services as options that can be exercised beyond the baseline.

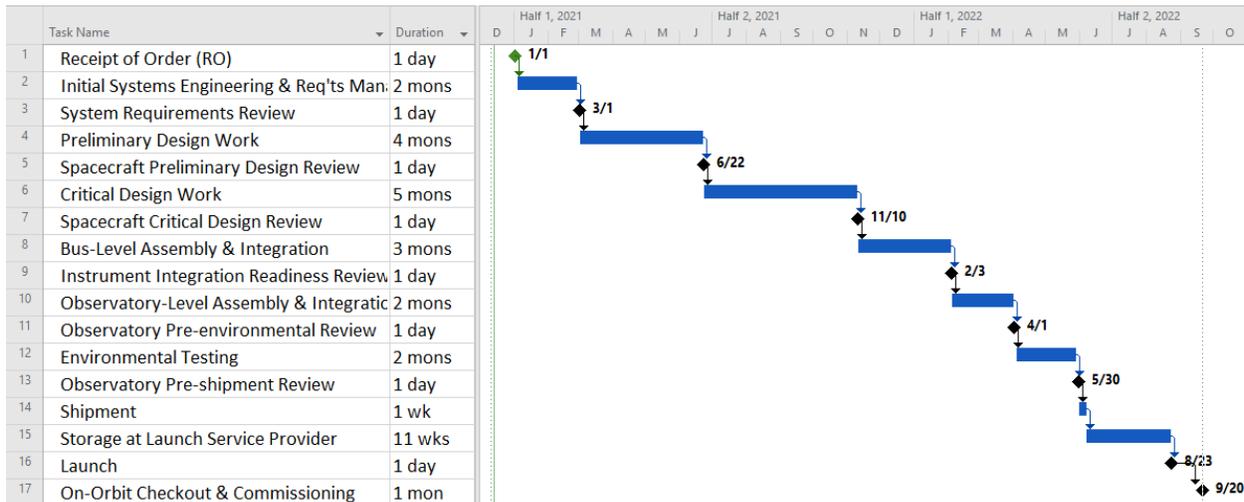
Facilities

Tyvak manufactures tight-tolerance mechanical parts for aerospace applications within its 12,000-ft² machine shop located in Santa Maria, CA, which boasts state-of-the art CNC lathes and mills and precision metrology equipment. Once parts are machined and verified for tolerance, they are shipped to Tyvak’s headquarters facility in Irvine, CA, for bus/payload assembly, integration, and testing (AI&T). Over half of this 40,000-ft² facility is dedicated lab space which houses state-of-the-art equipment to support the manufacturing and AI&T of new space systems.

Included within this 25,000-ft² satellite and satellite accessory fabrication and test lab are ESD-compliant lab benches, laminar flow benches, electronics and mechanical assembly areas, a class 100,000 clean assembly area, thermal and thermal vacuum chambers, an electronics laboratory for module testing and verification, a large anechoic chamber, a dedicated RF laboratory, random vibration testing equipment, and extensive networking and computing infrastructure. In addition, Tyvak’s 4,000-ft² dedicated ICD-705-compliant SCIF laboratory space enables assembly and integration of classified payloads at its headquarters facility. This facility also features walled offices, open cubicle areas, and conference rooms to support over 100 engineering and administrative staff.

Tyvak’s headquarters facility also features a dedicated mission operations center (MOC), which is equipped to manage multiple vehicles and missions simultaneously. Combined with Tyvak’s global ground station network, Tyvak’s MOC provides actionable, low-latency information to its customers and end-users around the clock. Tyvak’s mission operations department manages on-orbit vehicles following deployment from the launch vehicle. The team manages vehicles for the entire duration of the mission. This includes commissioning, vehicle checkout, payload operations, vehicle monitoring and maintenance, and decommissioning. The mission operations team fully staffs vehicle operations 24/7 during early orbit operations, commissioning, and critical mission segments. Outside of commissioning and critical events, mission operations can be set to reduced staffing levels while fully monitoring vehicle health using an automated ground monitoring system.

Contract Baseline Delivery Schedule



Trestles 6U/12U Platform Specifications

	Property	Unit	Tyvak Trestles 6U	Tyvak Trestles 12U
Compatibility	Stowed Dimensions	mm	117 x 245 x 366	228 x 245 x 366
	Deployed Dimensions	mm	1525 x 245 x 366	1626 x 245 x 366
	Bus Dry Mass (no PL)	kg	7.69	9.5
	Max Payload Mass	kg	7.31	15.5
	Payload OAP (EOL)	W (EOL)	35	60
	Science Data Downlink	kbps	< 2048	< 2048
	Science Data Storage (Capacity)	Mbit	< 49152	< 49152
	Pointing Knowledge (1σ)	arcsec	25	25
	Pointing Control (1σ)	arcsec	50	50
	Pointing Stability (1σ)	arcsec/sec	10	10
	Slew Rate	deg/min	180	120
	Mission Design Life	years	2	2+
	Compatible LVs	names	All major rockets (Vega, PSLV, RocketLab, Virgin, Falcon 9, Soyuz, LauncherOne, etc.)	All major rockets (Vega, PSLV, RocketLab, Virgin, Falcon 9, Soyuz, LauncherOne, etc.)
	Nominal Orbit	alt., incl., type, other	500 km, 98 deg, Sun Synch	500 km, 98 deg, Sun Synch
	Types of Orbits Available	as needed	Compatible with a vast range of orbits (LEO, GEO, interplanetary). Any inclination for Earth orbits is supported	Compatible with a vast range of orbits (LEO, GEO, interplanetary). Any inclination for Earth orbits is supported
	External PL Volume	cubic meters	N/A	N/A
Internal PL Volume	cubic meters	3.33 x 10 ⁻³	14.40 x 10 ⁻³	
Thermal Accommodations	as needed	Thermal isolation from bus; heater power supplied	Thermal isolation from bus; heater power supplied	
Heater Power Provided	W	Nominally, 5 W OAP, 10 W peak; flexible	Nominally, 5 W OAP, 10 W peak; flexible	
Programmatic & Other	Heritage Missions	names	Tyvak-0129 Tyvak-0171 Tyvak-0172 Tyvak-0123	Tyvak-0129 Tyvak-0171 Tyvak-0172 Tyvak-0123
	Nominal Schedule (ATP to Payload I&T)	months	14	14
	Nominal Schedule (ATP to Launch)	months	18	18
Description	ACS	type	3-axis	3-axis
	Star Trackers	# of STs	2	2
	GPS	# receivers	1	1
	Batteries	cell type/capacity (Ah)	Li-ion, 12.5 Ah	Li-ion, 12.5 Ah
	Bus Voltage Range	volts	9.0–12.6	9.0–12.6
	C&DH Bus Arch.	description	RS-422/485, Ethernet, USB 2.0	RS-422/485, Ethernet, USB 2.0
	C&DH Data Rate	kbps	> 1024	> 1024
	Communication Band	S, X, UHF, etc.	UHF-band, S-band	UHF-band, S-band
	Structure	description	Al 7075 6U	Al 7075 12U
	Propulsion	type, fuel	N/A	N/A
	Propellant Capacity	kg	N/A	N/A
Max ΔV	m/s	N/A	N/A	

Rapid Spacecraft Development Office (RSDO)
 NASA Goddard Space Flight Center
 Mail Code 401.1
 Greenbelt MD 20771 USA
 Phone: 301-286-1289
 Email to: rsdo@rsdo.gsfc.nasa.gov