TubeSat and NEPTUNE 30 Orbital Rocket Programs

Personal Satellites Are GO!
Corporation
Founded in 1996 by Randa and Roderick Milliron, incorporated in 2001
Located at the Mojave Spaceport in Mojave, California
98.5% owned by R. and R. Milliron
1.5% owned by Eric Gullichsen

Initial Starting Technology
Pressure-fed liquid rocket engines

Initial Mission
Low-cost orbital and interplanetary launch vehicle development

Facilities
6,000 square-foot research and development facility
Two rocket engine test sites at the Mojave Spaceport
Expert engineering and manufacturing team
Roderick Milliron: Chief Designer
Lutz Kayser: Primary Technical Consultant
Eric Gullichsen: Guidance and Control
Gerard Auvray: Telecommunications Engineer
Donald P. Bennett: Mechanical Engineer
David Silsbee: Electronics Engineer
Joel Kegel: Manufacturing/Engineering Tech
Jacqueline Wein: Manufacturing/Engineering Tech
Reinhold Ziegler: Space-Based Power Systems
E. Mark Shusterman, M.D.: Medical Life Support
Randa Milliron: High-Temperature Composites
Propellant Tanks: Combining state-of-the-art composite technology with off-the-shelf aluminum liners

Advanced Guidance Hardware and Software

Ablative Rocket Engines and Components

GPRE 0.5KNFA Rocket Engine Test

Manned Space Flight Training Systems

Rocket Injectors, Valves Systems, and Other Metal components

Interorbital Systems
www.interorbital.com
**Pressure-Fed Rocket Engines**

GPRE 2.5KLMA Liquid Oxygen/Methanol Engine: Thrust = 2,500 lbs.
GPRE 0.5KNFA WFNA/Furfuryl Alcohol (hypergolic): Thrust = 500 lbs.
GPRE 0.5KNHXA WFNA/Turpentine (hypergolic): Thrust = 500 lbs.
GPRE 3.0KNFA WFNA/Furfuryl Alcohol (hypergolic): Thrust = 3,000 lbs.
GPRE 10.0KNHXA WFNA/Turpentine (Hypergolic): Thrust = 10,000 lbs.

**Pressure-Fed Sounding Rockets**

Neutrino: GPRE 0.5NFA Engine
Tachyon: GPRE 3.0KNHXA Engine

**Manned Systems**

Dick Rutan’s Global Hilton Project
Helium/Hot Air Balloon System Propane Tanks
NEPTUNE Modular Series Orbital Launch Vehicles
- NEPTUNE 30 (30 kg to LEO)
- NEPTUNE 1000 (1000 kg to LEO)
- NEPTUNE 4000 (4000 kg to LEO)

Orbital Spacecraft
- Orbital Expedition Crew Modules (6-person capacity)
- Robotic Orbital Supply System (ROSS)

Interplanetary Spacecraft
- Google Lunar X PRIZE Lunar Lander
- Robotic InterPlanetary Prospector Excavator Retriever (RIPPER)

Satellite Design and Manufacture
- TubeSat
Low-Cost Pico Satellite Kit – The TubeSat
Satellite casing and satellite ejection system are constructed from off-the-shelf aluminum tubing
Manufacturing requires minimal machining
Makes use of the latest developments in off-the-shelf electronics
Makes use of highly efficient solar cells (26% efficiency)
Simple satellite ejection system allows TubeSats to be launched one at a time or in groups of 32
Each TubeSat never comes in contact with other TubeSats in a launch group

Low-Cost Dedicated Launch Vehicle – NEPTUNE 30
All TubeSats have primary payload status
The new IOS TubeSat Personal Satellite Kit is a low-cost alternative to the CubeSat. It has three-quarters of the weight and volume of a CubeSat (weight = 0.75 kg or 1.65 lbs). Still offers plenty of space for most experiments or applications.

The price of the TubeSat Kit ($8,000) includes the price of a launch into Low-Earth-Orbit on an IOS NEPTUNE 30 rocket.

Since TubeSats are placed into self-decaying orbits (310 km), they do not contribute to the long-term buildup of orbital debris.

After a few weeks of operation, they re-enter the atmosphere and burn-up.

Launches are expected to begin in the fourth quarter of 2010.
General Description
  Cylinder shaped
  Maximum weight: 0.75 kg
  Satellite bus or stand-alone satellite

Power
  Batteries: lithium ion 3.6 V
  Solar Cells: Spectrolab 2.52 V 31 mA (multiples)
  Power management board

Transceiver Options:
  Microhard n425, n920, or n2420
  Frequency range: 400 to 450 MHz 902 to 928 MHz or 2.4000 to 2.4835 GHz
  Voltage: 3.3 VDC
  Output: 100 mW to 1,000 mW Selectable

Microcomputer Hardware
  BasicX-24p
  Rogue Robotics uMMC serial Data Module

Antennas
  Dipole
TubeSat Component Layout

Solar Cell and Antenna Placement

TubeSat Component Rack

- Experiment or Application
- Microcomputer and Memory Board
- Transceiver
- Power Management Board
- Battery Pack
TubeSat Deployment System

Interorbital Systems
www.interorbital.com
Earth-from-space video imaging

Earth magnetic field measurement

Satellite orientation detection (horizon sensor, gyros, accelerometers, etc.)

Amateur radio relay

Orbital environment measurements (temperature, pressure, radiation, etc.)

On-orbit hardware and software component testing (microprocessors, etc.)

Tracking migratory animals from orbit

Testing satellite stabilization methods

Biological experimentation

Automatic simple, repeating “message from orbit” transmission

Private e-mail

The builder can add any type of electronics or software application he or she wishes as long as it satisfies the volume and mass restrictions. These restrictions provide a unique intellectual challenge for the application designer.
Call-in or e-mail tech support (Interorbital and/or University partners)

Dedicated support page at www.tubesat.org (coming soon)

On-line password-accessed users’ forums

Constantly updated FAQs

Quarterly (or more frequent) user’s workshops on-ground or on-line

TubeSat Kit User’s Manual
Environmentally Safe, Storable, High-Density Hypergolic Propellants
White Fuming Nitric Acid (WFNA) and Turpentine/Furfuryl Alcohol
Instantaneous chemical ignition eliminates need for complex ignition system

Low-Cost Propellant Tank Technology
Off-the-shelf aluminum tank liners and tank ends
State-of-the-art composite tank reinforcement technology

Blowdown Propellant Feed
Eliminates the need for turbopumps or a separate pressurant system

Unique Rocket Engine Injector
Automatically maintains propellant jet flow rate in blowdown mode
Maximizes specific impulse over a wide pressure input range

Differential Throttling Rocket Steering Technology
Allows all rocket engines to be fixed
Eliminates complex gimballing or fluid injection steering systems
There are no steering penalties such as jet-vane drag loss
Rockets with throttleable engines don’t require hold downs

Modular Rocket System – The Common Propulsion Module (CPM)
Only small rocket engines have to be developed
Small rocket engines cost less to develop
Small diameter tanks don’t require slosh baffles
Individual rocket modules can be flight tested at a very low cost
Launch vehicle can be customized for any payload
The Common Propulsion Module (CPM) is the Basic Building Block of all Neptune Modular Series Rockets. The CPMs can be clustered together in multiples for both small and large orbital and interplanetary payloads. Clustered engines have been in use since the beginning of the race for space. Below is an aft view of the Russian Soyuz rocket with a cluster of 32 engines. The Soyuz rocket is the most reliable rocket in the world.
Neptune 30 Modular System

3 stages

31 feet (9.4 m) in length with a maximum width of 6.2 feet (1.89 m)
The GLOW is 18,700 pounds (8,841 kg)
Five (5) Common Propulsion Modules
Satellite Module has a solid kick motor (Thrust = 1,500 lbs.)
Booster Thrust = 4 X 10,000 lbs = 40,000 Lbs SL (177,920 n)

Interorbital Systems
www.interorbital.com
Nitric Acid: Von Braun’s Oxidizer of Choice

Wernher von Braun: NASA, OTRAG

Lutz Kayser: OTRAG and Rod Milliron: Interorbital

Hypergolic

Interorbital Systems
www.interorbital.com
High-density (1.51) storable oxidizer: White Fuming Nitric Acid (WFNA)
Storable fuels: Turpentine and Furfuryl Alcohol
WFNA is corrosive but non-flammable and non-toxic
Long-term Storage possible in the propellant tanks
Turpentine furfuryl alcohol are denser than kerosene
Insulated storage tanks not required
Orbital launch vehicle history (Diamant A rocket)
Rocket engine system components have already been successfully tested

Propellant tank components have been successfully tested

Guidance and Control System has been successfully bench tested

Test infrastructure is already in place (vertical test stand and test site hardware)

Propellant and COTS component suppliers have been identified

Launch site secured on an island in the South Pacific Kingdom of Tonga

Design and manufacturing team is already in place

No existing competition at this price, value, launch frequency, or performance level
**Ground Systems**
- Ground transport system
- Launch platform
- Rocket lift system
- Propellant loading system
- Launch control system
- Ground communications system

**Rocket Communication Systems**
- Transceivers
- Antennas

**General Launch Procedure**

**Rocket Hardware**
- Rocket engine/motor performance in flight
- Reaction control system
- Rocket engine throttling system
- Rocket structural characteristics in flight
- Rocket stability in flight
- Grid-fin effectiveness criteria in flight
- Payload ejection system
- Recovery system
- Rocket staging system
- Spin stabilization

**Guidance and Control**
- Inertial measurement unit
- Guidance computer
- Guidance software
Common Propulsion Module (CPM) Flight Tests

Launch 1:
Location: Mojave Test Area  
Rocket: Common Propulsion Module  
Altitude: 50,000 feet (15.3 km)  
Payload: TubeSats and TubeSat deployment system or other  
Purpose: Test systems described under Neptune 30 Test Program  
Time Frame: Jan/Feb 2010

Launch 2:
Location: Mojave Test Area  
Rocket: Common Propulsion Module  
Altitude: 50,000 feet (15.3 km)  
Payload: TubeSats and TubeSat deployment system or other  
Purpose: Test systems described under Neptune 30 Test Program with modifications if required  
Time Frame: April/May 2010

Launch 3:
Location: Mojave Test Area  
Rocket: Satellite Module with solid rocket motor  
Altitude: 20,000 feet (6.1 km)  
Payload: TubeSats and TubeSat deployment system or other  
Purpose: Test spin stabilization system  
Time Frame: June 2010
NEPTUNE 30 Flight Tests

Launch 1:
Location: Mojave Test Area or Delamar Dry Lake
Rocket: NEPTUNE 30 with dummy core stage and Satellite Module
Altitude: 50,000 feet (15.3 km)
Payload: TubeSats and TubeSat deployment system or other
Purpose: Test systems described under Neptune 30 Test Program
- Test Satellite Module spin-up and deployment system (with recovery)
- Test differential thrust steering system
- Test rocket stability at Mach 1 and at maximum dynamic pressure
- Test staging system
Time Frame: August/September 2010

Launch 2:
Location: Tonga Spaceport
Rocket: NEPTUNE 30
Altitude: 312 km (193.3 mi)
Payload: 32 TubeSats and TubeSat deployment system or other
Purpose: First orbital satellite launch
Time Frame: November/December 2010
Common Propulsion Module, Satellite Module, or Staging Test

Maximum Payload: 30 kg
Payload Type:
- Up to 32 TubeSats
- Up to 15 CubeSats
- Single Payload

CPM test vehicle is recoverable

Orbital Launch

Maximum Payload: 30 kg
Payload Type:
- Up to 32 TubeSats
- Up to 15 CubeSats with 5 P-Pods
- Single satellite with deployment system
LAUNCH SCENARIO

- Satellite Module Spin-up
- Core Stage Shutdown
- Satellite Module Ejection
- Strap-On Boosters Jettisoned
- Core Stage Ignition
- Climb and Pitchover
- Launch Preparation
- Pre Launch
- Booster Engines (4) Ignition: Launch

Satellite Module Coast Phase

(1) - Satellite Module Enters Orbit
(8)
(6)
(7) Satellite Module Burn
FAA/AST launch license for orbital launches: in process

IOS held one of the first Commercial Space Transportation Launch Licenses (LLS 00-054, October, 2000) for Tachyon sounding rocket

Obtained: Two active 365-day FAA waivers for pre-orbital flight tests to 50,000 ft. at Mojave Test Area, California, and at Delamar Dry Lake, Nevada
IOS' Tongan Spaceport

Kingdom of Tonga
Latitude: 21.45 degrees S
Longitude: 174.90 degrees W

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