Nano-Launcher: Dedicated Nanosatellite Payload Delivery Service

2010 CubeSat Developers' Summer Workshop | 07-08 August 2010 | Logan, Utah USA

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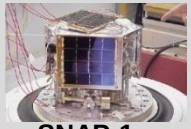
Nanosatellite Revolution

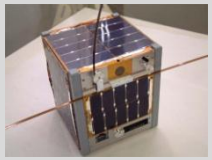
- Sputnik shock => Gagarin shock => Man on the moon => CubeSat shock?
- Globalizing and Internationalizing ORS Standards and Technology (GIST)
- PnP spacecraft architectures accelerate modularization and standardization
- Advances in nanosatellite technologies, developers, and missions
- Strong demand for an affordable nano and micro-sat dedicated launch vehicle

PIONEER
Experiment
& University,GOV


CP-1


SNAP-1


AerospaceCorp Picosat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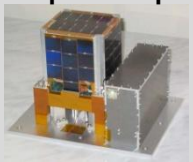
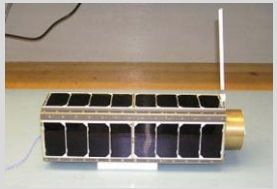

CUTE-1

PRESENT
Experiment
& University, School, GOV, Company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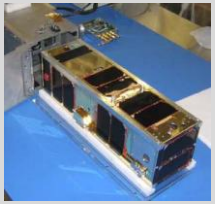
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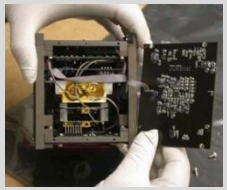
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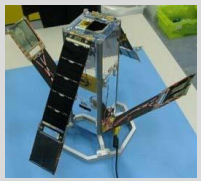
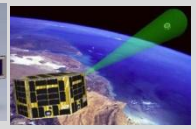
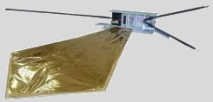
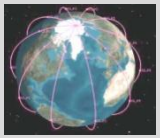
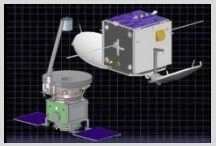

Delfi-C3

FUTURE
Experiment/Mission Application &Anyone

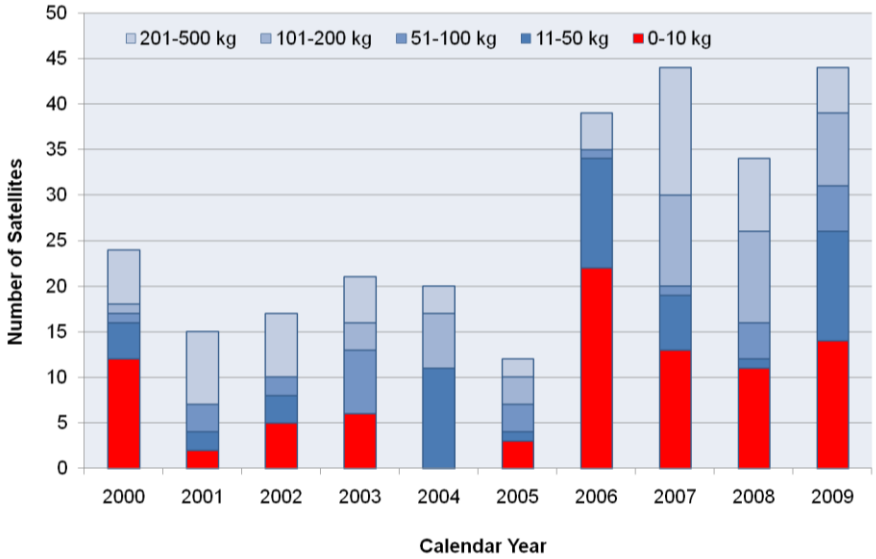







- More hi-ISP & thrust
- More power & storage
- More hi-speed data rate
- More Operational
- Smaller Bus system(MEMS)
- More sensitive attitude control
- Standardization(PnP,GIST,,)
- Commercialization

Image sources:Aerospace Corp, U-Tokyo, Titech, Calpoly,SSTL, Boeing, NASA,UTIAS, tudelft, U3P,US-Army,Boeing, DARPA, AFRL, INSA, Northrop Grumman

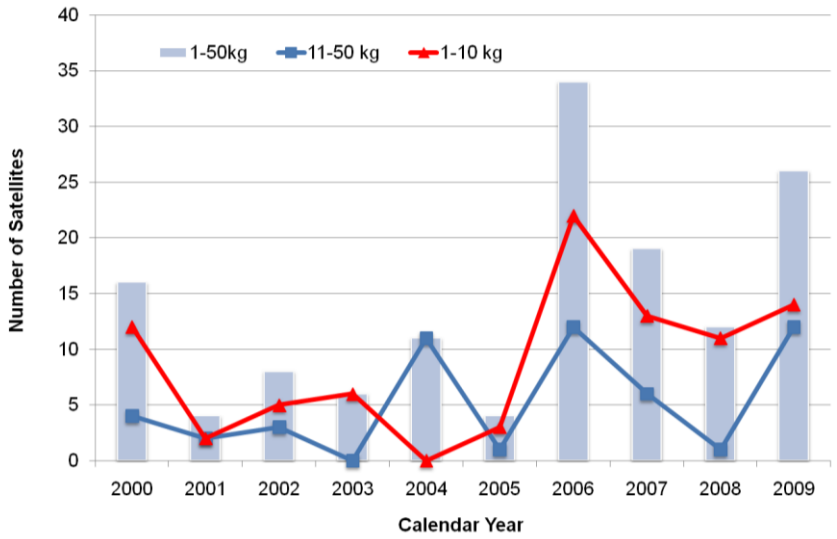
Nanolaunch capability is critical to the sustaining the innovation wave in nano-space

The Small Satellite Market: 2000-2009



Number of Attempted Small Satellites Launches: 2000-2009 for 1-500 kg Satellite Class

Source: SpaceWorks Commercial
Global Small Satellite Launch Database



Yearly Launch History: 2000-2009 for 1-50 Kg Satellite Class

Source: SpaceWorks Commercial
Global Small Satellite Launch Database

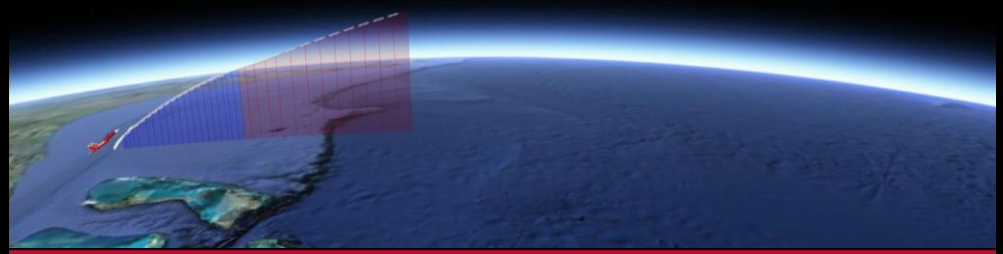
Long term forecasting (2010-2014) indicates growing market for launch services

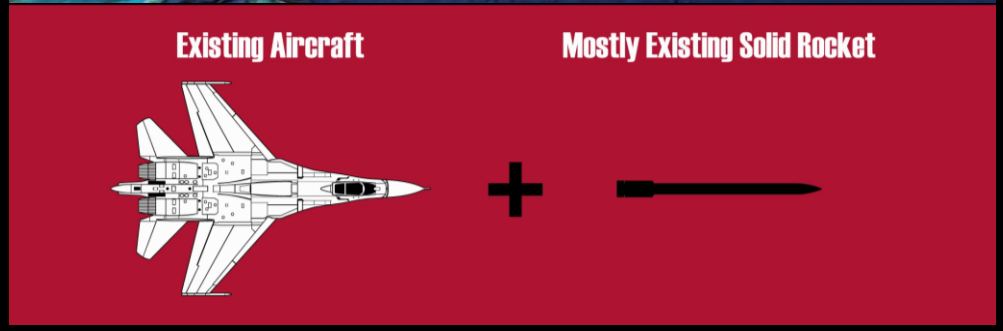
More detailed paper to be presented at AIAA Space 2010 on market assessment:
J. Depasquale, et al, "Analysis of the Earth-to-Orbit Launch Market for Nano and Microsatellites," AIAA SPACE 2010 Conference & Exposition (Session 002-CS-1, 03:00pm, 30 August 2010).

Notes:
•The database contains all attempted launches. Unless otherwise indicated all data points mentioned below refer to attempted launches.
•It should also be noted that the number of satellites launched may not equal the number of launches in any given year since many satellites are multiple-manifested (i.e. more than one satellite on a particular launch).
•Many times in this presentation, the term "launch" or "launches" may refer to the number of satellites launched (even though they may be multiple-manifested).

NanoLauncher

Dedicated Nanosatellite Delivery to Low Earth Orbit





suborbital

NanoLauncher BLUE

orbital

NanoLauncher BLACK

NanoLauncher Vision

- Develop a customer-oriented, dedicated small payload launch service that is robust, reliable, and scalable to service an underserved niche of the launch market
  - Orbital (NanoLauncher Black), Suborbital (NanoLauncher Blue)
- Air-launch offers potential interesting launch and range capabilities
  - Initial launch site in U.S. with potential for global expansion
- Use lessons learned from past incomplete programs
  - Base system on mostly existing elements wherever possible (aircraft, rockets, payload integration), evolution of technology
  - Design to general capability and not requirement (“flexible path”)
  - Leverage other development projects (aircraft, range, avionics)
  - International partnerships to allocate overall risk over multiple parties, leverage best range, global customer marketing
    - IHI Aerospace (IA), SpaceWorks Commercial, USEF, and CSP Japan

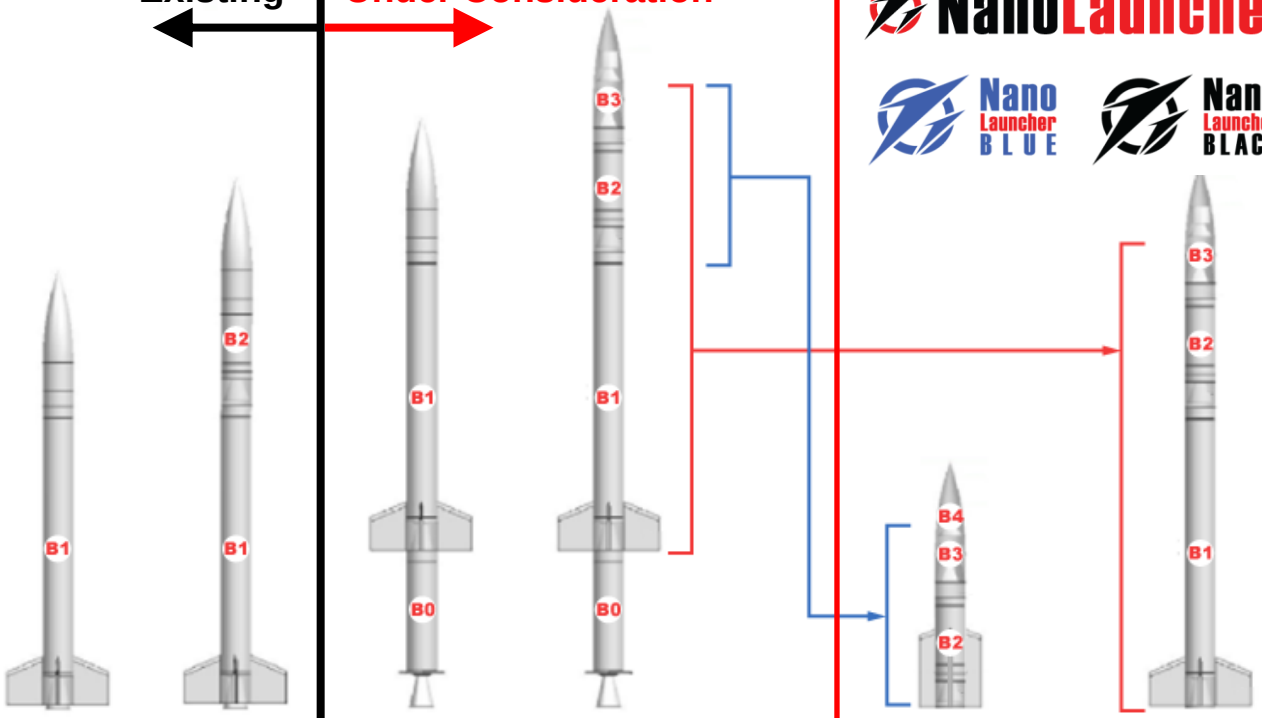
Note: SpaceWorks Commercial, a division of SpaceWorks Engineering, Inc. (SEI) is registered with the U.S. State Department (DDTC) as an exporter of defense services and as a broker, SEI is in the process of obtaining a Technical Assistance Agreement (TAA) for the NanoLauncher project

SpaceSpike-1 and 2:
Solid Rocket Elements of NanoLauncher

Existing | Under Consideration

NanoLauncher

Nano Launcher BLUE | Nano Launcher BLACK



	S-520	SS-520	NS-520	NL-520	SpaceSpike-1	SpaceSpike-2
Total Length	8.0 m	9.65 m	10.7 m	12.7 m	5.4 m	10.0 m
Diameter	0.52 m	0.52 m	0.52 m	0.52 m	0.52 m	0.52 m
Weight	2.1 ton	2.6 ton	2.9 ton	3.4 ton	1.2 ton	3.2 ton
Stages	1	2	2	4	3	3

Ground Launch

Air-Launch

Current Capability | Capability A | Capability B | Capability C

Candidate Air-Launch Carrier Aircraft Options

- Various candidate aircraft are being examined with various rocket combinations
- Factors of lease versus buy options and applicability to orbital and suborbital missions

F-104

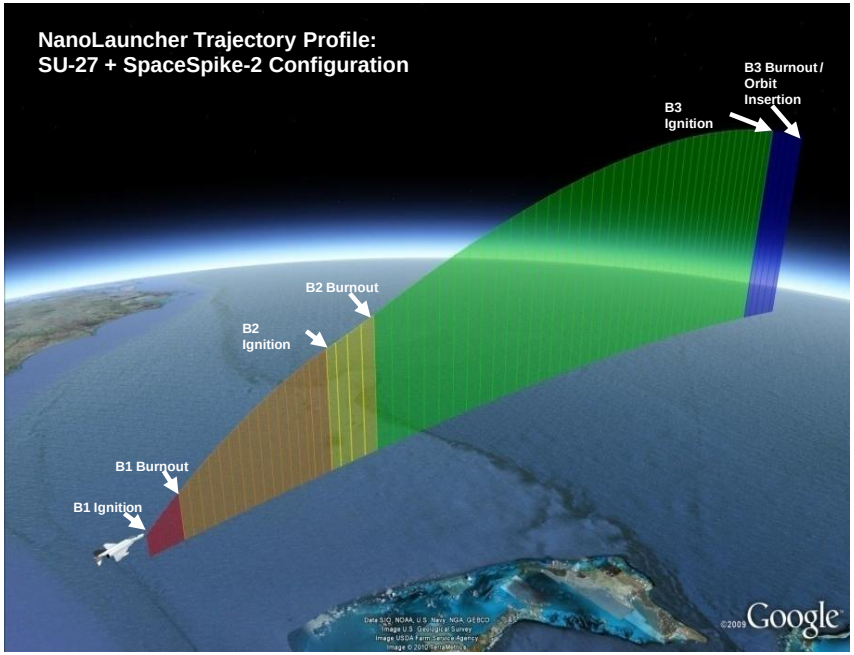
F-15D

SU-27

F-4

Final aircraft + rocket combination under assessment

NanoLauncher Black (orbital): SU-27 + SpaceSpike-2

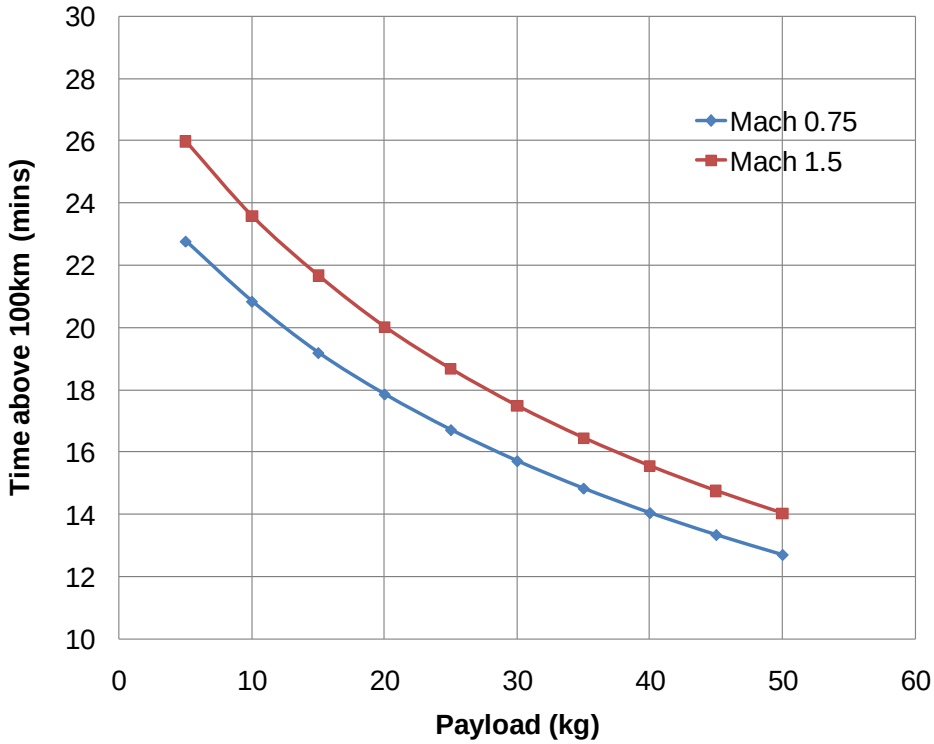


NanoLauncher BLACK

NanoLauncher Black (orbtial)
Preliminary Capability (payload to LEO):
SU-27+ three-stage SpaceSpike-2
<u>20 kg to LEO</u>

Final aircraft + rocket combination under assessment

NanoLauncher Blue (suborbital): F-104 / F-15 D + SpaceSpike-1



NanoLauncher Blue (suborbital)
Preliminary Capability (time above 100 km):
F-104 + two-stage SpaceSpike-1

Final aircraft + rocket combination under assessment

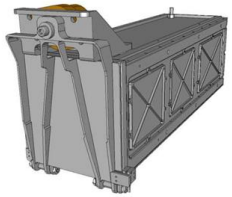
Payload Accommodation

Current Standards

- P-POD, NPSCul, RocketPods, SPL, ISIPOD, A-POD
- Independent Japan systems (T-POD, PHS, X-POD)

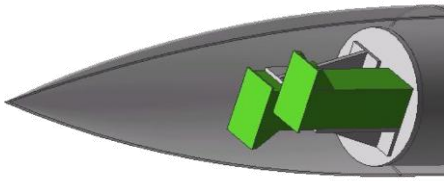
Future Standards

- Next generation P-POD (1U to 6U+)
- Nanosatellite Launch Adapter System (NLAS)

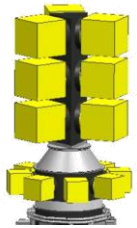


P-POD

Sounding Rocket Payload integration

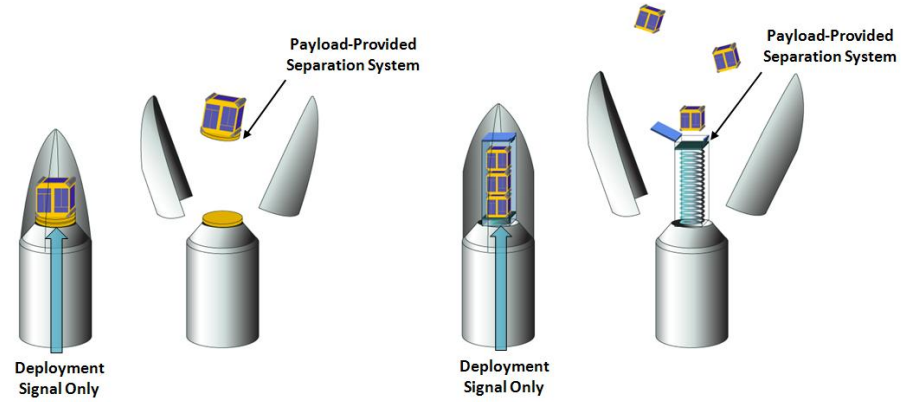


2 P-PODs loaded on NL-520

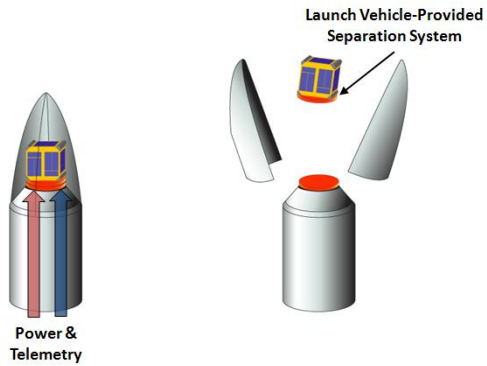


Multi-Launch Concept

A. Minimum Service Concept



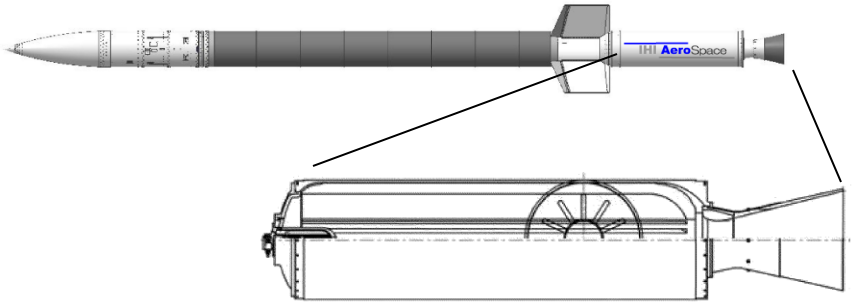
B. Full Service Concept



International cooperation on standards is key, fully treating nanosatellites as primary payloads may unlock greater mission capabilities

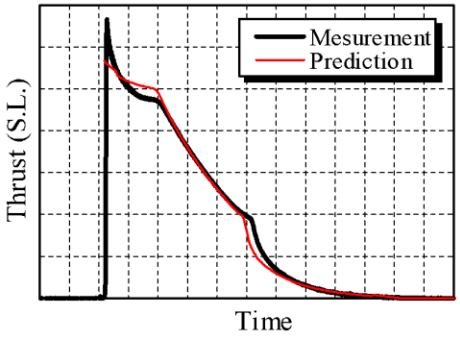
Technology Development: B0 Motor

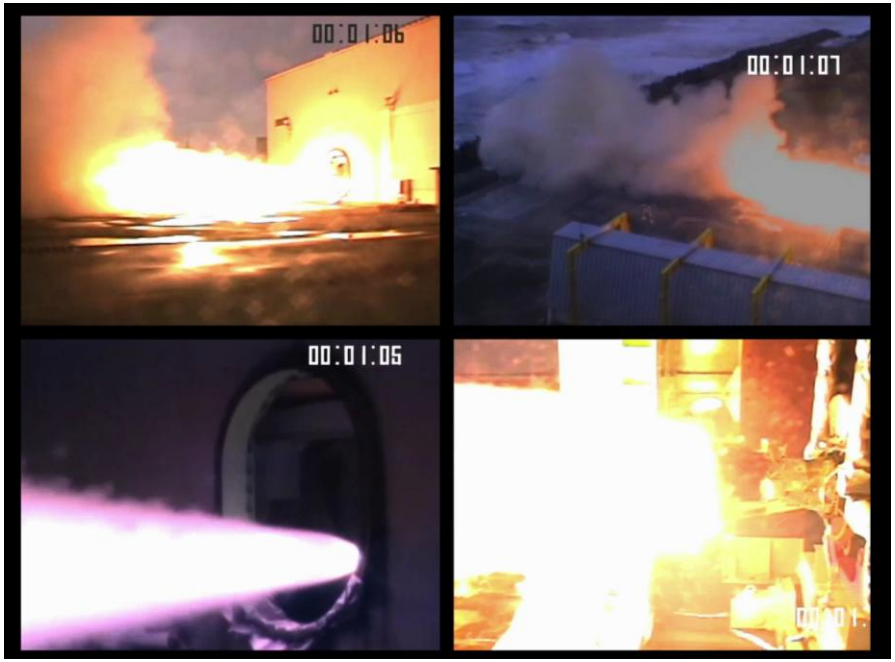
- Used to accelerate the NS-520 and the NL-520 to subsonic velocity
- Static firing test was successfully conducted in 2010



B0 MOTOR Specification

Item	Design	Test Result
Diameter	φ524 mm	←
Length	2,580 mm	←
Propellant	445 kg	444 kg
Maximum Thrust (Sea Level)	288 kN	330 kN

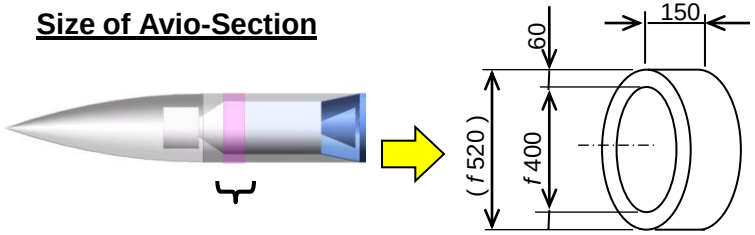




Technology Development: Miniaturized and Low-Cost Avionics System

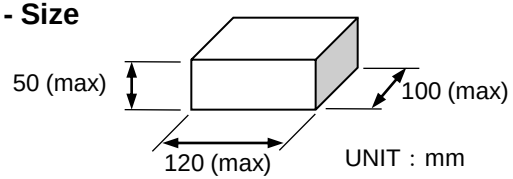
– **Proactive use of COTS components/parts including semiconductor relay and MEMS**

Size of Avio-Section

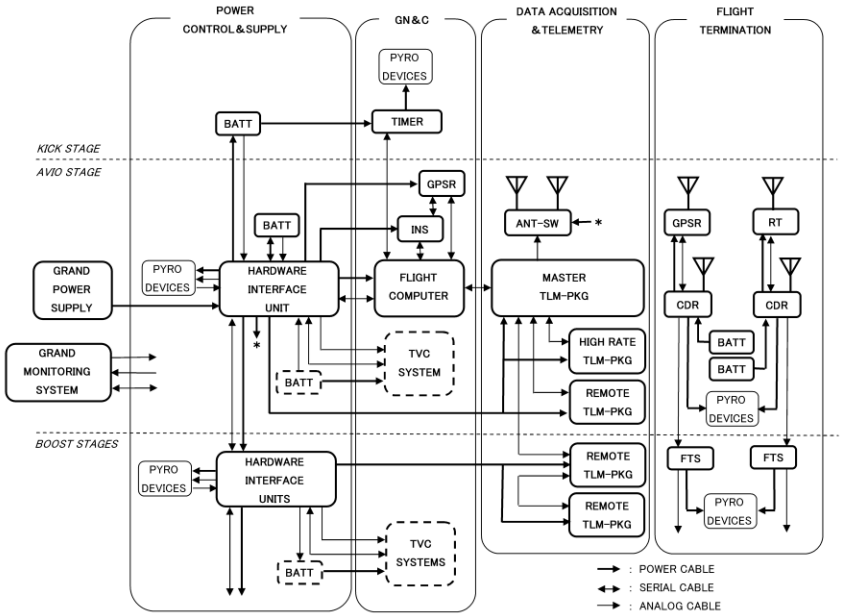


Requirement of Avionics Box

- Size



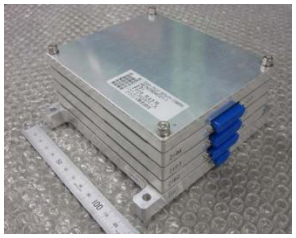
- Mass : less than 1kg/each



Avionics System Target Mass

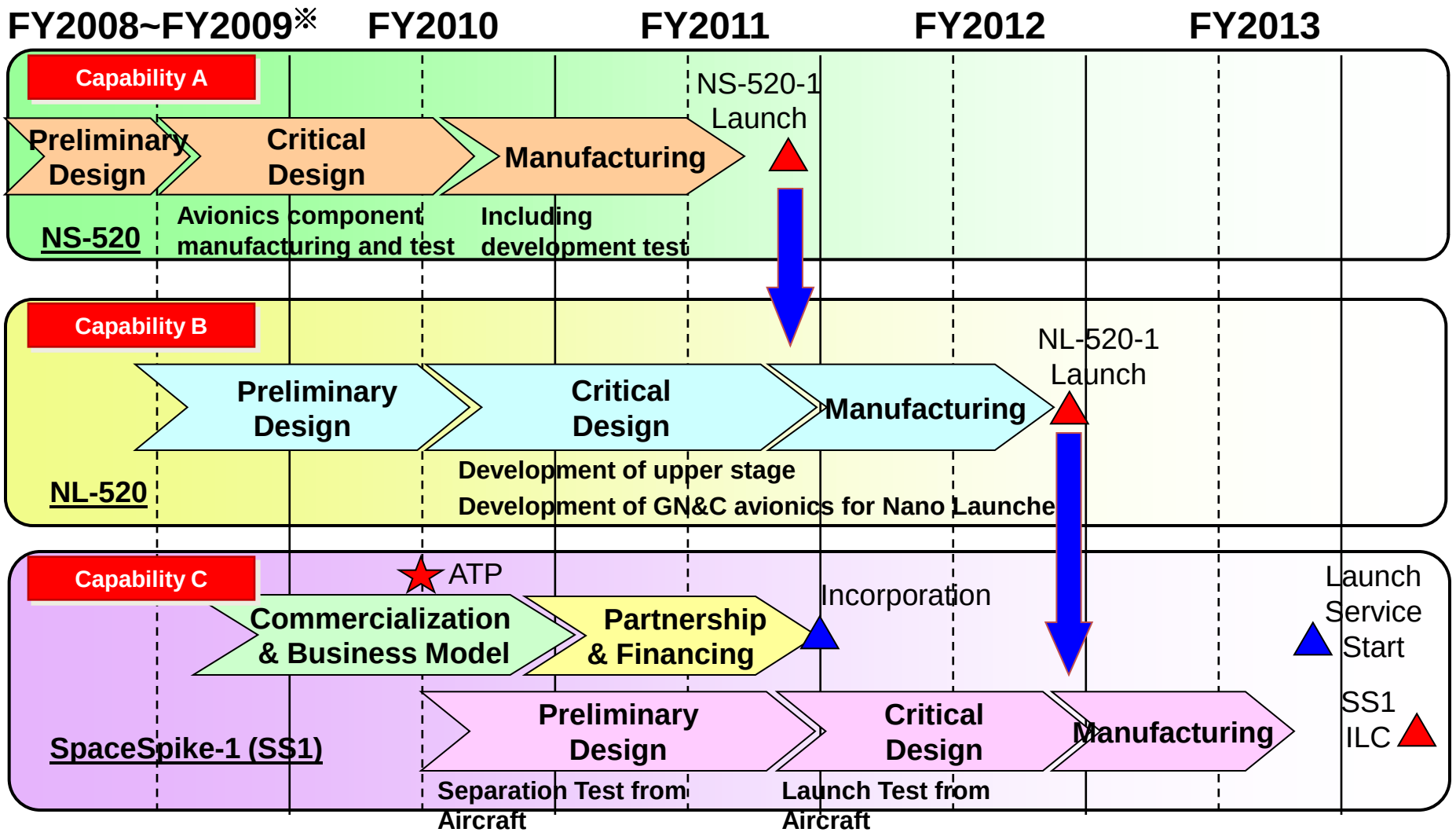
Item		Mass (kg)
GN & C		8
Data Acquisition and Telemetry		11
Power Control and Supply		8
Flight Termination	RT & Command	19
	Power Supply	6
TOTAL		52

Avionics System Functional Block Diagram



Prototypes of Miniaturized and Low-Cost Avionics

Roadmap: IA Rockets to NanoLauncher Service



Note: ※ Japanese fiscal year: from April 1 to March 31.

NanoLauncher Summary

- The nanosatellite wave will be an important force in the 21st century space launch environment (Historical and anecdotal evidence indicates growth)
- A dedicated NanoLauncher for such satellites is currently being designed to service such a market
  - The NanoLauncher is air-launch nano-satellite orbital payload delivery system
  - Based upon multi-stage derivatives of ISAS/JAXA's S-520 solid rocket coupled with an existing aircraft
  - Potentially for nano and micro satellites orbital delivery
  - Secondary missions for suborbital payloads
- International partnerships with private companies and institutional bodies is deemed to be a key strategy for overall risk reduction, global operability, schedule reduction and customer marketing
- Status
  - On-going technical and economic design proceeding (aircraft and rocket combinations including F-104, F-15D, SU-27, and F-4),
  - Customer pricing forthcoming
  - Solid rocket hardware and avionics development in Japan
  - Systems integration analysis and business development in the U.S.
  - Open to discussions with customers on payload accommodations
  - Open to discussions with potential risk-sharing partners

NanoLauncher

www.nanolauncher.com

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