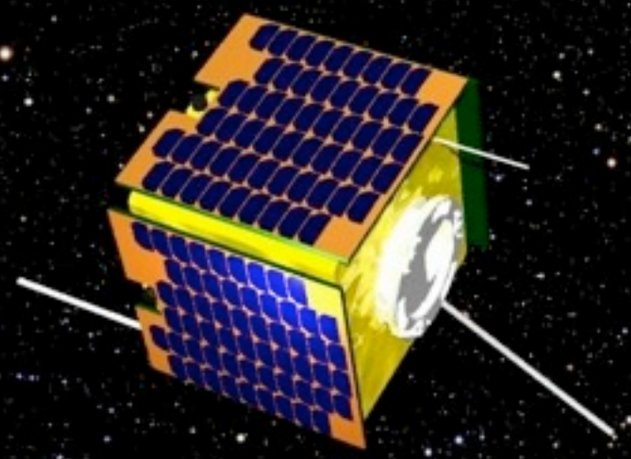
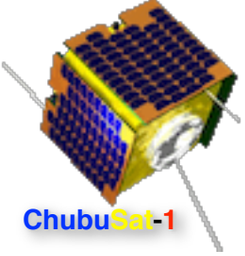


ChubuSat Project

Hiroyasu Tajima
Solar-Terrestrial Environment Laboratory,
Nagoya University

Outline

- Development of microsatellite
  - Backgrounds
  - Overview
  - Mission instruments
  - Launch vehicle
- Business prospects

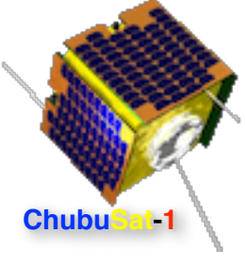


Categories of Satellites

Category	Mass	Sponsor	Applications
Large	> 500 kg	Government	intelligence, communication, broadcast, science
Small	100～500 kg	Government Venture Industry	remote sensing, intelligence, earth monitoring, science
Micro	1～100 kg	University Venture	education, technology development

Backgrounds

- Motivations
  - Lower barrier to enter space business by lowering cost
    - Expand commercial use of space
    - Expand market for aerospace industry in Chubu (central Japan) region
  - Test advanced technologies on orbit
    - Improve performance of future large scientific satellite
      - Large satellites usually do not use untested technologies
  - Enhance cooperation between academic and industries in Chubu region
- Goal
  - Reduce cost by a factor of 100
    - with “optimized” performance



Cost Reduction of Satellites

- Miniaturization
  - Tradeoff with functionalities and performance
    - Severe optimization of functionalities and performance
  - Optimum performance can be realized by taking advantage of technological advance
    - could be comparable with existing large satellites
      - Smaller imaging sensors → smaller lens and camera systems
- Make use of commercial parts (for automobile)
  - Reliable and low cost
  - SOC (system on chip) processors with SOI technologies
    - SOI = radiation hard
- Development of satellite for commercial use
  - Standardization of parts and interface
  - Designed for mass production
  - Reduce cost and time for satellite fabrications and assemblies

ChubuSat-1 Overview

Name: ChubuSat-1 金シャチ1号

"Kinshachi"

- **Specifications**
  - **Size: 58 cm × 55 cm × 50 cm**
  - **Mass: ~50 kg**
    - **Allows piggyback launch**
  - **Operation duration: 0.5 years min.**
    - **Radiation damages**
    - **Lifetime of rechargeable batteries**
    - **Radiator degradation due to atomic oxygen**
    - **satellite keeps orbiting after the end of operations**
  - **To be launched in 2013**
    - **Completed assembly and test of the satellite**

ChubuSat-1 Overview

Name: ChubuSat-1 金シャチ1号

“Kinshachi”

- **Specifications**
  - **Size: 58 cm × 55 cm × 50 cm**
  - **Mass: ~50 kg**
    - **Allows piggyback launch**
  - **Operation duration: 0.5 years min.**
    - **Radiation damages**
    - **Lifetime of rechargeable batteries**
    - **Radiator degradation due to atomic oxygen**
    - **satellite keeps orbiting after the end of operations**
  - **To be launched in 2013**
    - **Completed assembly and test of the satellite**

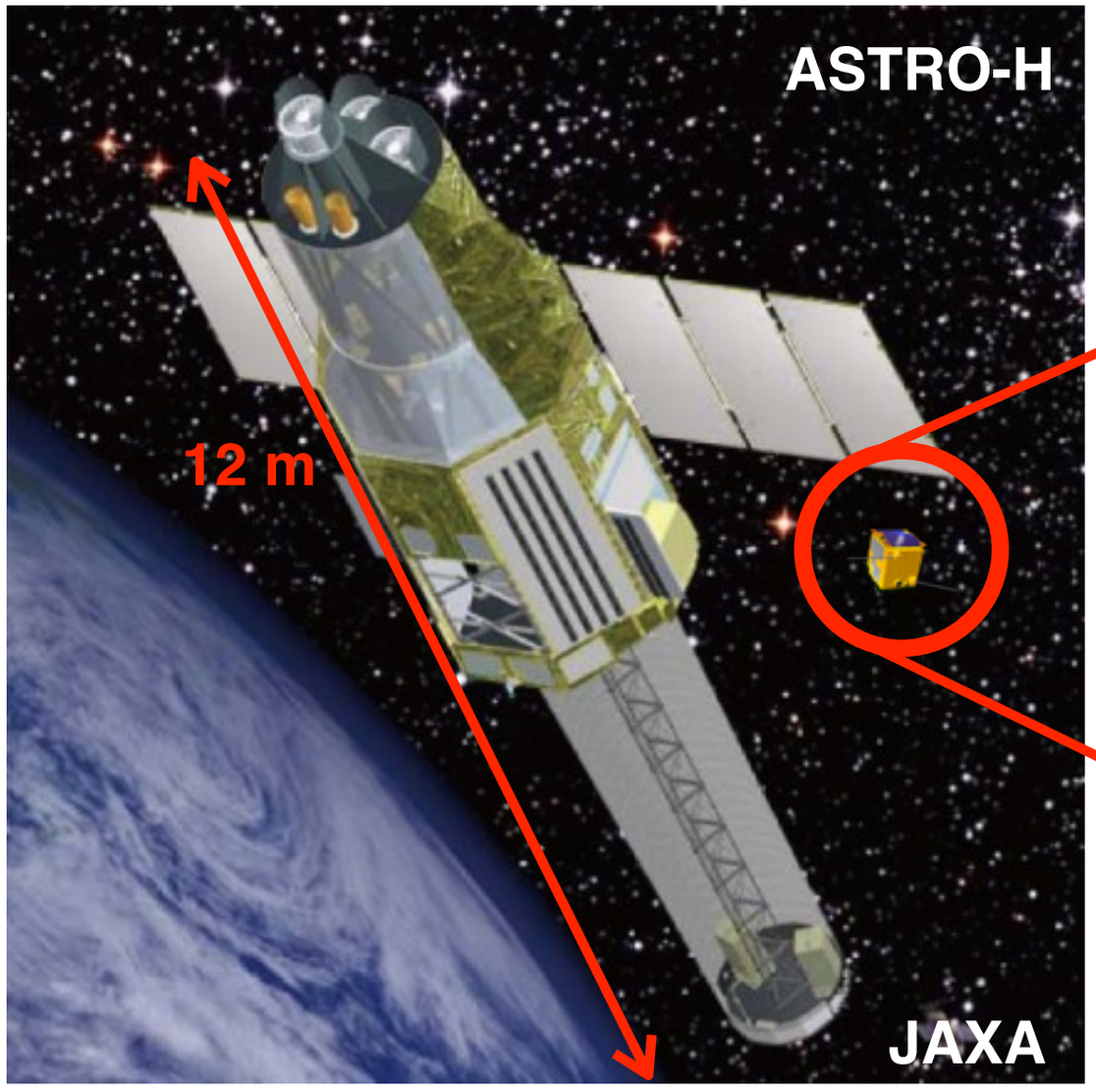
ChubuSat-1 Overview

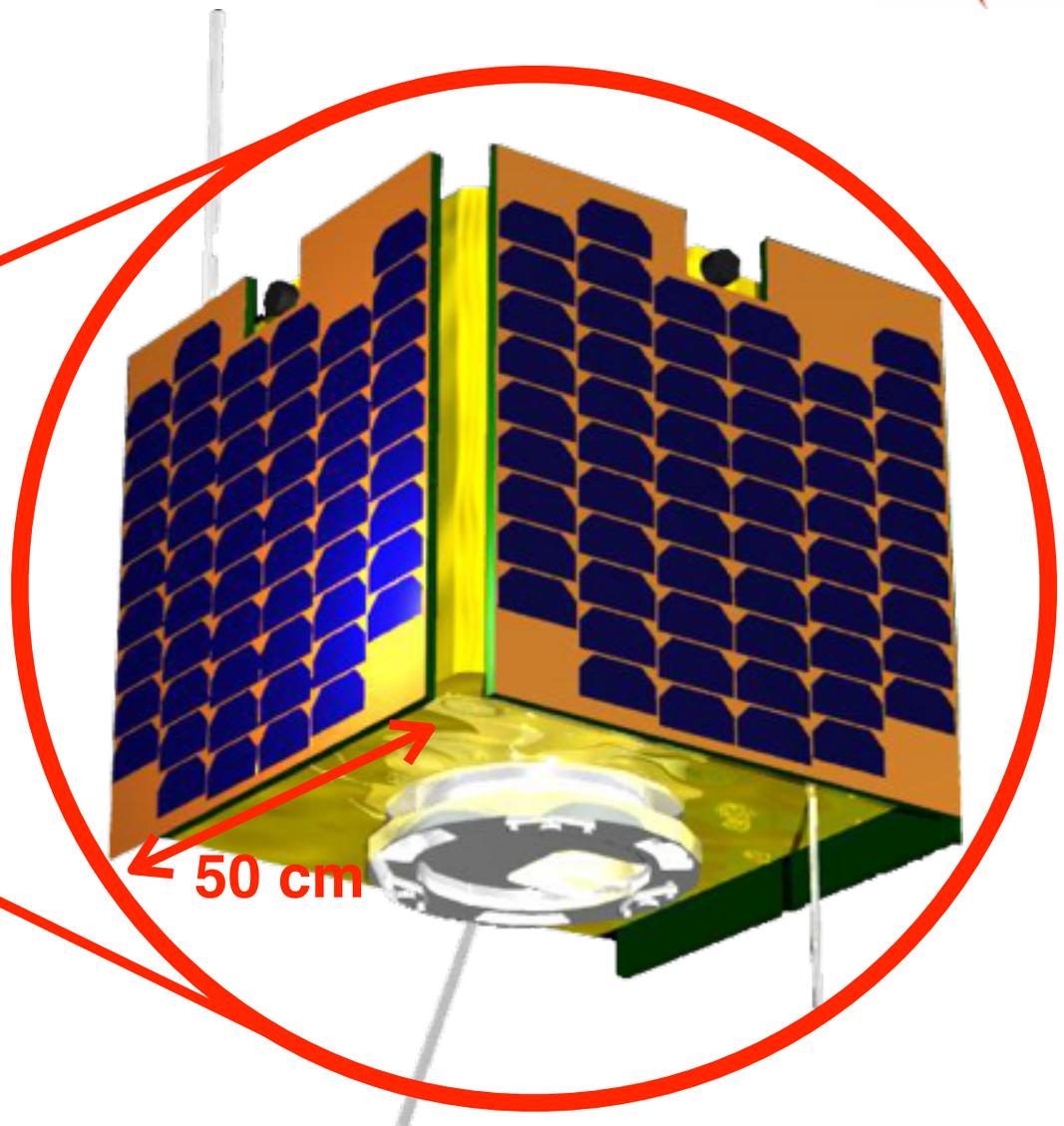
Name: ChubuSat-1 金シャチ1号

"Kinshachi"

- Specifications
  - Size: 58 cm × 55 cm × 50 cm
  - Mass: ~50 kg
    - Allows piggyback launch
  - Operation duration: 0.5 years min.
    - Radiation damages
    - Lifetime of rechargeable batteries
    - Radiator degradation due to atomic oxygen
    - satellite keeps orbiting after the end of operations
  - To be launched in 2013
    - Completed assembly and test of the satellite

Comparison with Large Satellite

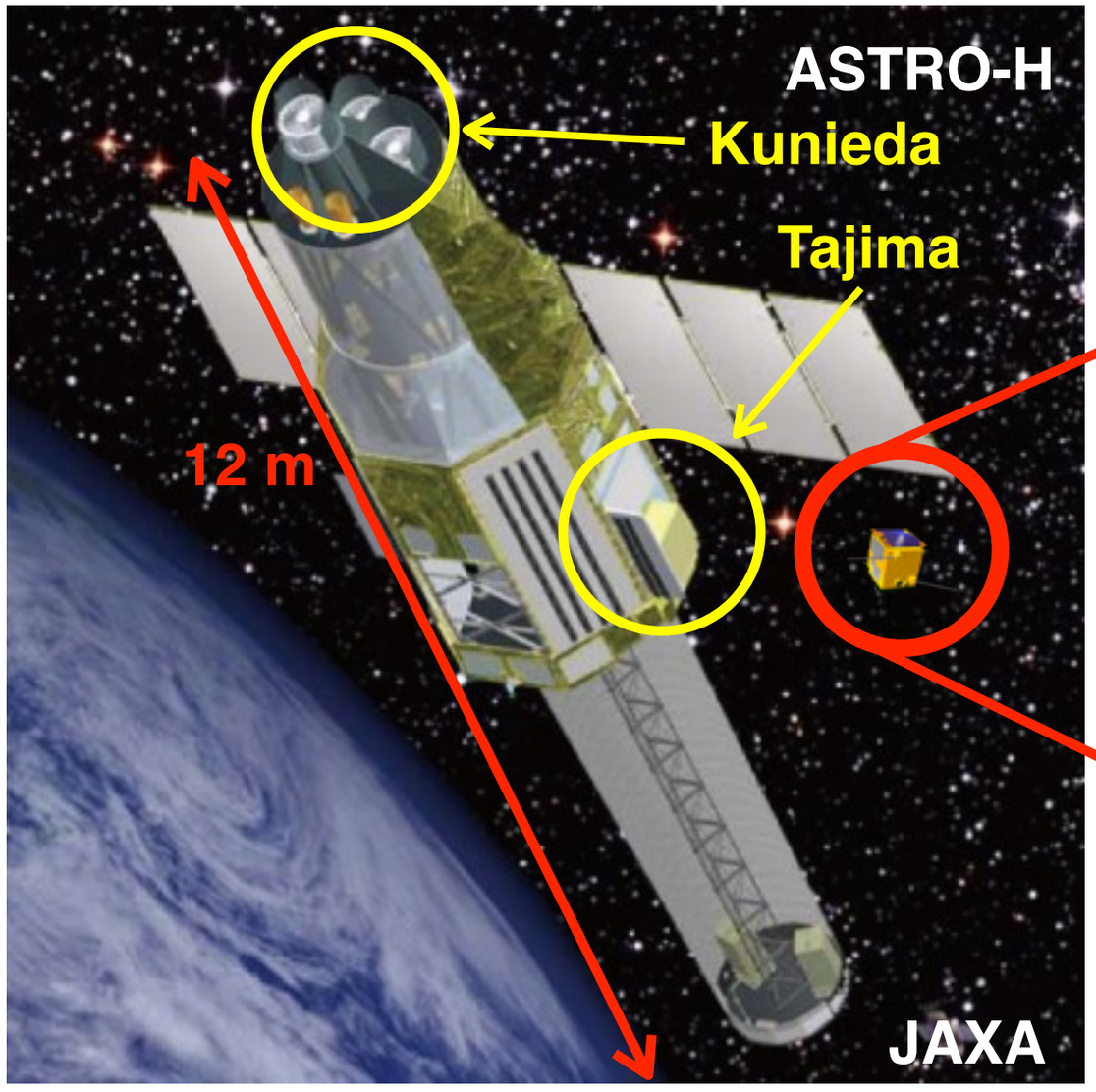




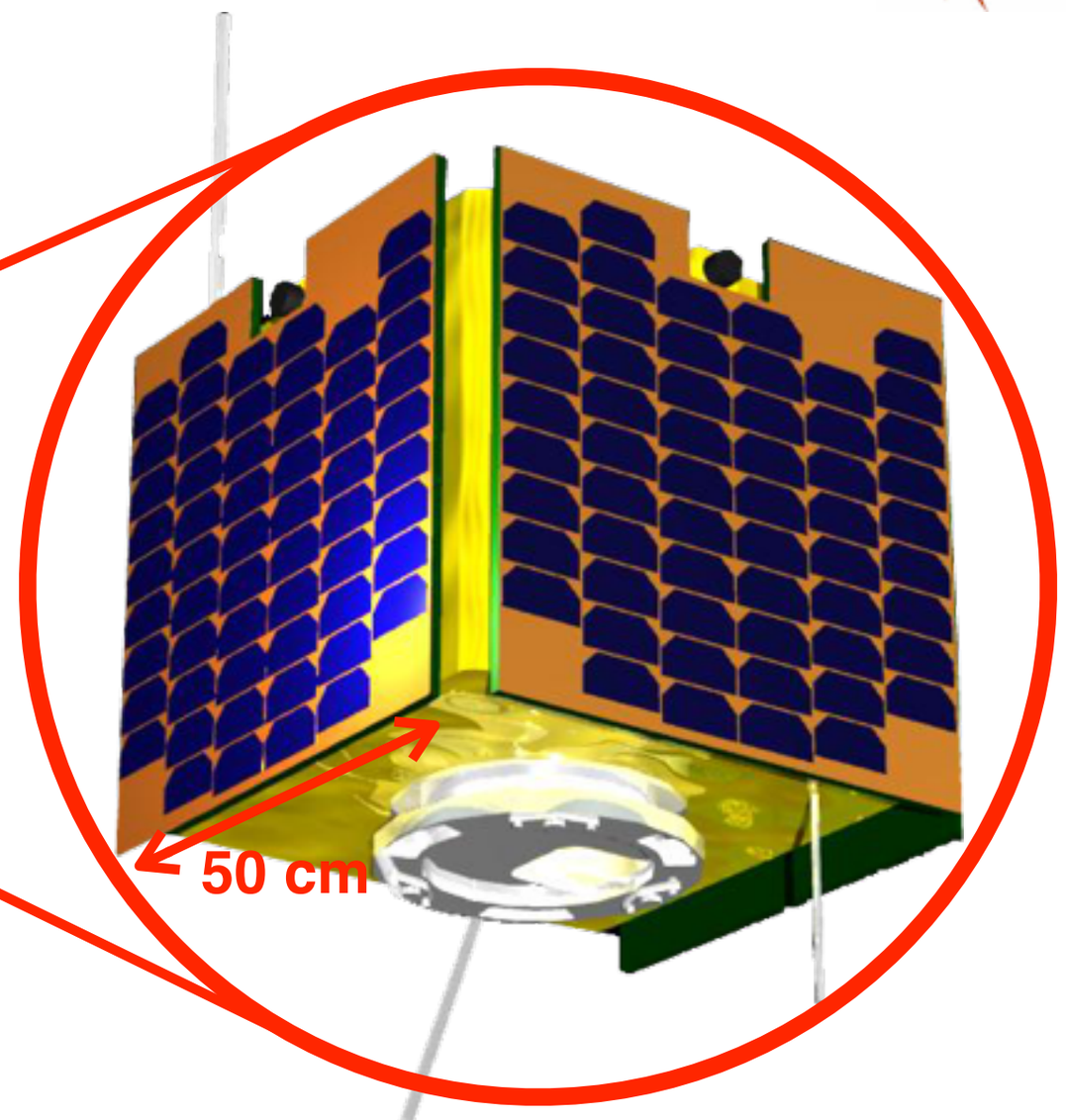
Mass: 2,700 kg
Length: 12 m
Cost: ~20B JPY
Life: > 3 years
Development : >7 years

Mass: 50 kg
Length: 50 cm
Cost: ~300M JPY
Life: > 0.5 years
Development: < 2 years

Comparison with Large Satellite



Mass: 2,700 kg
Length: 12 m
Cost: ~20B JPY
Life: > 3 years
Development : >7 years



Mass: 50 kg
Length: 50 cm
Cost: ~300M JPY
Life: > 0.5 years
Development: < 2 years

Project Team

Daido University
Masanobu Mizoguchi
(Deputy PM)

Nagoya University
Hiroyasu Tajima
(Project Manager)

Association of Chubu region aerospace industries

Daido University
Nagoya University

- System design
- Test planning
- Mission instrument tests
- Ground station

Association of Chubu region aerospace industries

- Satellite fabrications and assemblies

Daido University
Nagoya University

- Analysis and tests

Collaborating partners

- Development of optical camera
(Tokyo University of Science, Kimura group)
- Remote ground station
(Luleå University of Technology)
- Environmental tests
(Kyushu Institute of Technology)

Association of Chubu region aerospace industries

- 35% of Boeing 787 parts are produced in Chubu, Japan
- Small (and medeium-sized) business with advanced technologies

（株）光製作所
HIKARI MANUFACTURE CO., LTD.
機械加工を中心に量産から個別、治工具、試験器等の設計製作を得意とする。
Machining specialist, mid to special large size part made from Ni-,Ti-,Fe-,Al-alloy.Available for Fixtures and Testing devise from design to manufacturing.

伊藤鉄工（株）
ITO TEKKO CO., LTD.
・高品質・短納期体制の確立。
・スクラップ、廃油処理を含めた環境対応型企業経営。
Machining specialist, mid to large part, Ni-, Al-alloy.

平和産業（株）
HEIWA SANGYO CO., LTD.
切削加工で三菱重工業をサポートしています。
Machining specialist, mid to large size part made from Ni-, Ti-, Fe-, Al-alloy.

（株）小坂鉄工所
KOSAKA IRON WORKS CO., LTD.
航空機精密小部品多種少量加工を得意とする。
Machining specialist, high accuracy small part made from Ni-, Fe-, Al-alloy.

（株）興功社
SHINKOSHA CO., LTD.
総合小物加工の匠集団。
―素材から完成まで―
Machining specialist, small part made from Fe-alloy.

エヌティー精密（株）
NT SEIMITSU CORPORATION
薄肉異・低コスト・環境対応に向けた物作り。
Machining specialist, small part made from Fe-alloy.

ミツ精機（株）
MITSU SEIKI CO., LTD.
技術開発企業として世界の空へ。
Machining specialist, mid to large size part made from Ni-, Ti-, Fe-, Al-alloy.

（株）ナサダ
NASADA CO., LTD.
航空機エンジンケースの生産を得意とする。
Machining specialist, mid to large size part made from Ni-, Ti-, Fe-alloy.

（株）山之内製作所
YAMANOUCHI CO., LTD.
チタン、インコネル等の超精密機械加工。
Machining specialist, mid to large size part made from Ni-, Ti-, Fe-, Al-alloy.

瑞浪精機（株）
MIZUNAMI SEIKI CO., LTD.
自動車（陸）船舶（海）飛行機（空）の関連部品を製造しています。
Machining specialist, small part made from Fe-alloy.

（株）加藤製作所
KATO MANUFACTURING CO., LTD.
24時間稼動の"MS"を実力にしています。
Machining specialist, small part made from Fe-alloy.

（株）松浦
MATSUURA CO., LTD.
板金加工、溶接、（手）仕上げを主に、一連の物作りが可能な設備を用意しています。
Sheet metal forming, welding assembly and deburring specialist.

（株）三光製作所
SANKO MFG CO., LTD.
精密針加工のパイオニア。
Machining specialist, mid size part made from Ni-, Fe-alloy.

（株）磯村製作所
ISOMURA INDUSTRIAL CO., LTD.
顧客満足のために!
Machining specialist, mid size part made from Ni-, Fe-, Al-alloy.

アイコクアルファ（株）
AIKOKU ALPHA CORPORATION
世界最先端技術を駆使した5軸特殊加工。
Machining specialist, mid size part made from Ni-, Ti-, Fe-alloy, plenty experience for manufacturing impeller.

APCエアロスペシャルティ（株）
APC AEROSPECIALTY INC.
ECM加工のスペシャリスト。
ECM Specialist, experience for manufacturing impellers and bladed wheels.

旭金属工業（株）
ASAHI KINZOKU KOGYO INC.
加工から表面処理、組立までの一貫生産。
Surface treatment specialist, total manufacturing through from machining to surface treatment.

（株）放電精密加工研究所
HODEN SEIMITSU KAKO KENKYUSHO CO.,LTD.
放電加工から特殊工程まで独自技術開発で未来を拓く放電精密。
EDM and Coating specialist, small to large size part.

玉川工業（株）
TAMAGAWA INDUSTRIES CO., LTD.
旋盤、マシセンからの精密、放電の細削加工が得意。
Machining specialist, mid size part made from Ni-, Fe-alloy, and available for EDM.

（株）瑞木製作所
MIZUKI INDUSTRIAL CO., LTD.
インコ・チタン加工／経産省のサポイン受託。
Machining specialist, mid size part made from Ni-, Fe-alloy.

マツダ化工（株）
MATSUDA KAKO CO., LTD.
Ecology-Qualityを重視した企業です。
Fixture manufacture, available from small to Large size.

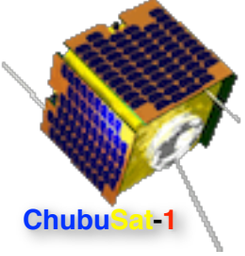
東明工業（株）
TOHMEI INDUSTRIES CO., LTD.
各種試験装置等設計から組立まで対応致します。
Function Test devise from design to assembly.

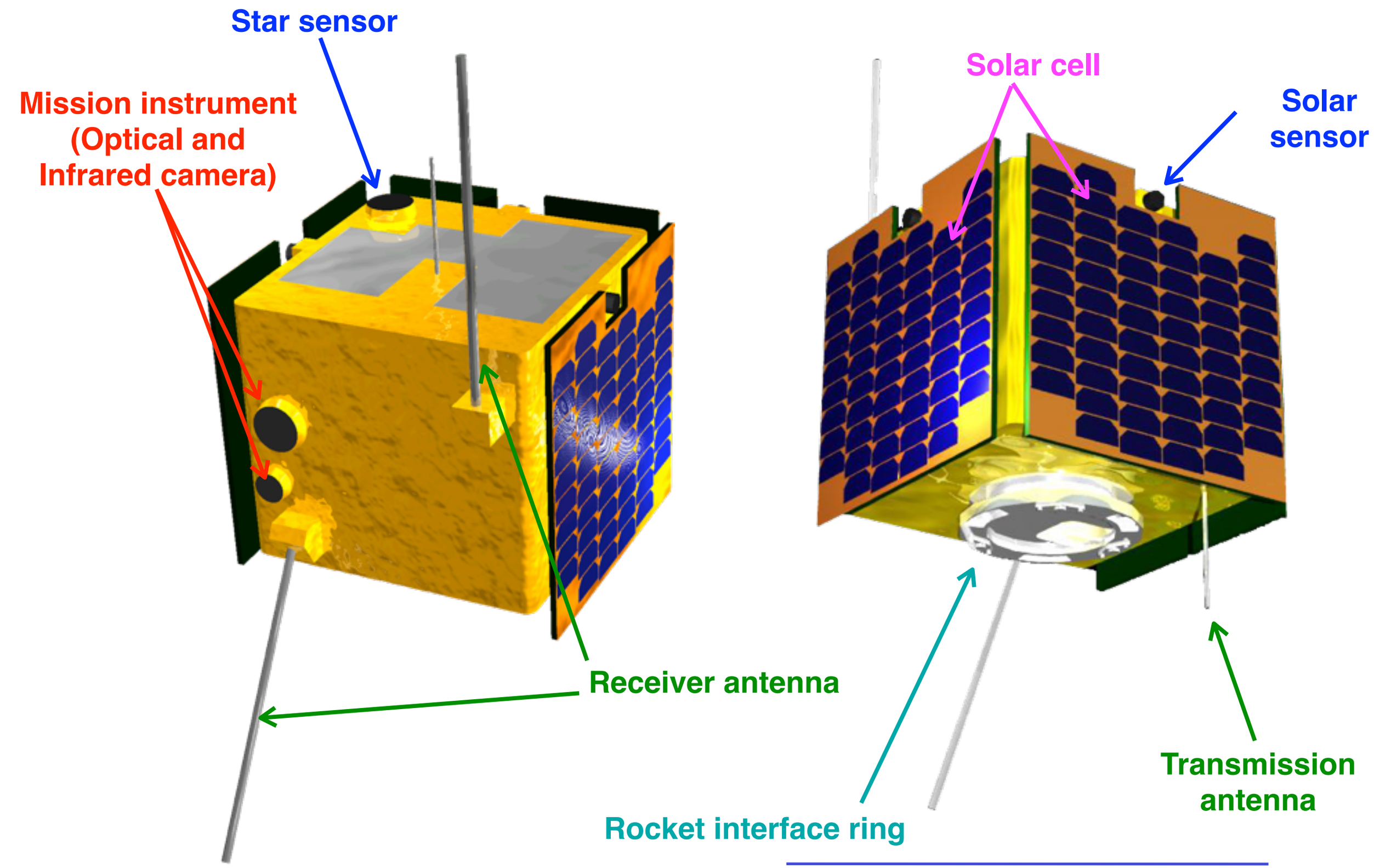
三友工業（株）
SANYU INDUSTRIES, LTD.
各種の自動化省力化設備メーカー。
Equipment maker, automatic and labor saving system.

東洋航空電子（株）
TOYO KOKU DENSHI CO., LTD.
ワイヤーハーネスと独立支援装置の製造メーカー。
Wiring &GSE Manufacture.

: contributing to ChubuSat-1

ChubuSat-1


ChubuSat-1


Star sensor
Mission instrument
(Optical and
Infrared camera)
Solar cell
Solar
sensor
Receiver antenna
Rocket interface ring
Transmission
antenna

Mission Instruments

- Optical and infrared cameras to
- Amateur radio equipment for data transfer and commands
  - It is used for communications for only small fraction of time
  - Messaging services can be provided when unused

Optical camera

- CMOS
- pixel pitch: 3.5 μm
- # of pixels: 320 x 240
- FOV: 2.2° x 1.6°

1 pixel corresponds to 10 m

Infrared camera

- Bolometer
- pixel pitch: 25 μm
- # of pixels: 320 x 240
- FOV: 4.6° x 3.7°

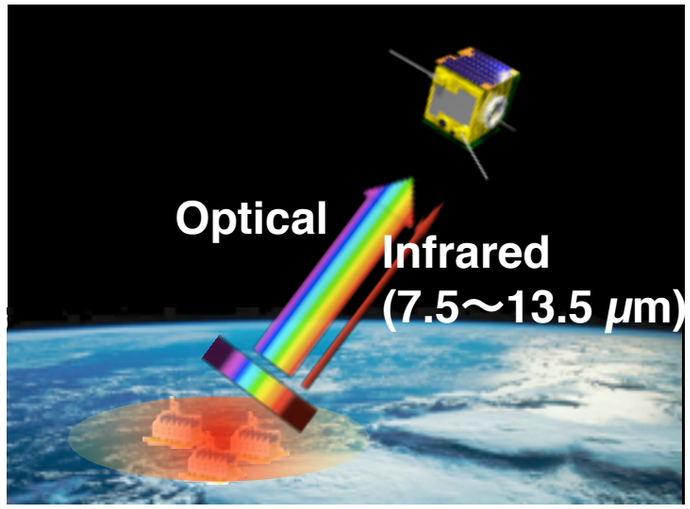
1 pixel corresponds to 140 m

Amateur radio

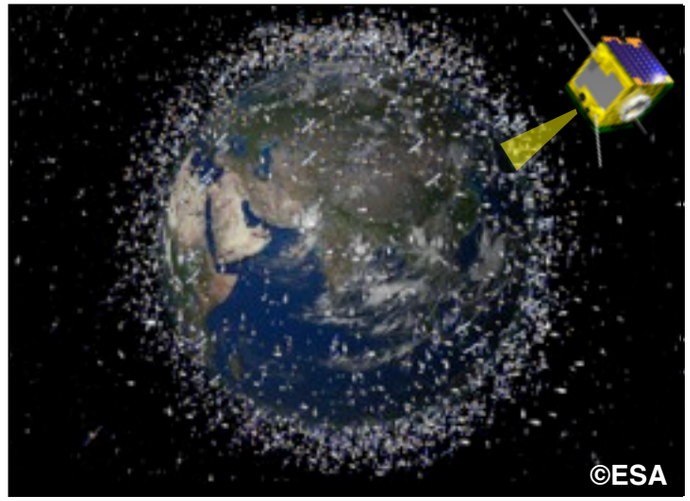
- Up Link: 1.2kbps@145.8MHz
- Down Link : 9.6kbps@437.0MHz

Observation Plans Overview

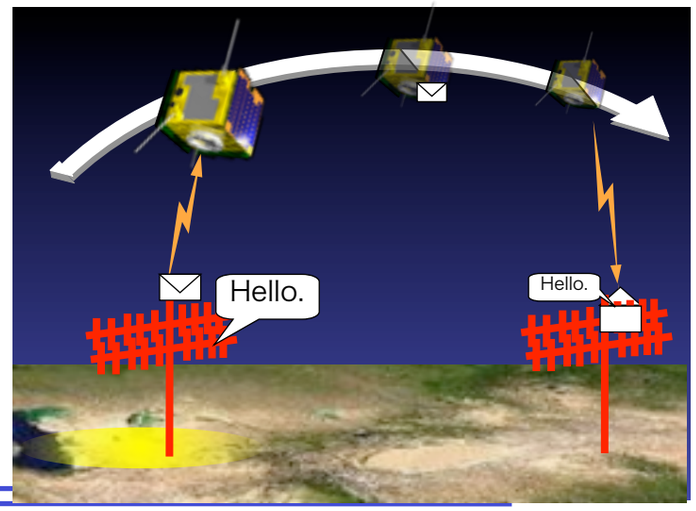
- Remote sensing
  - Take picture of Earth surface with optical and infrared cameras
  - Infrared camera provides temperature



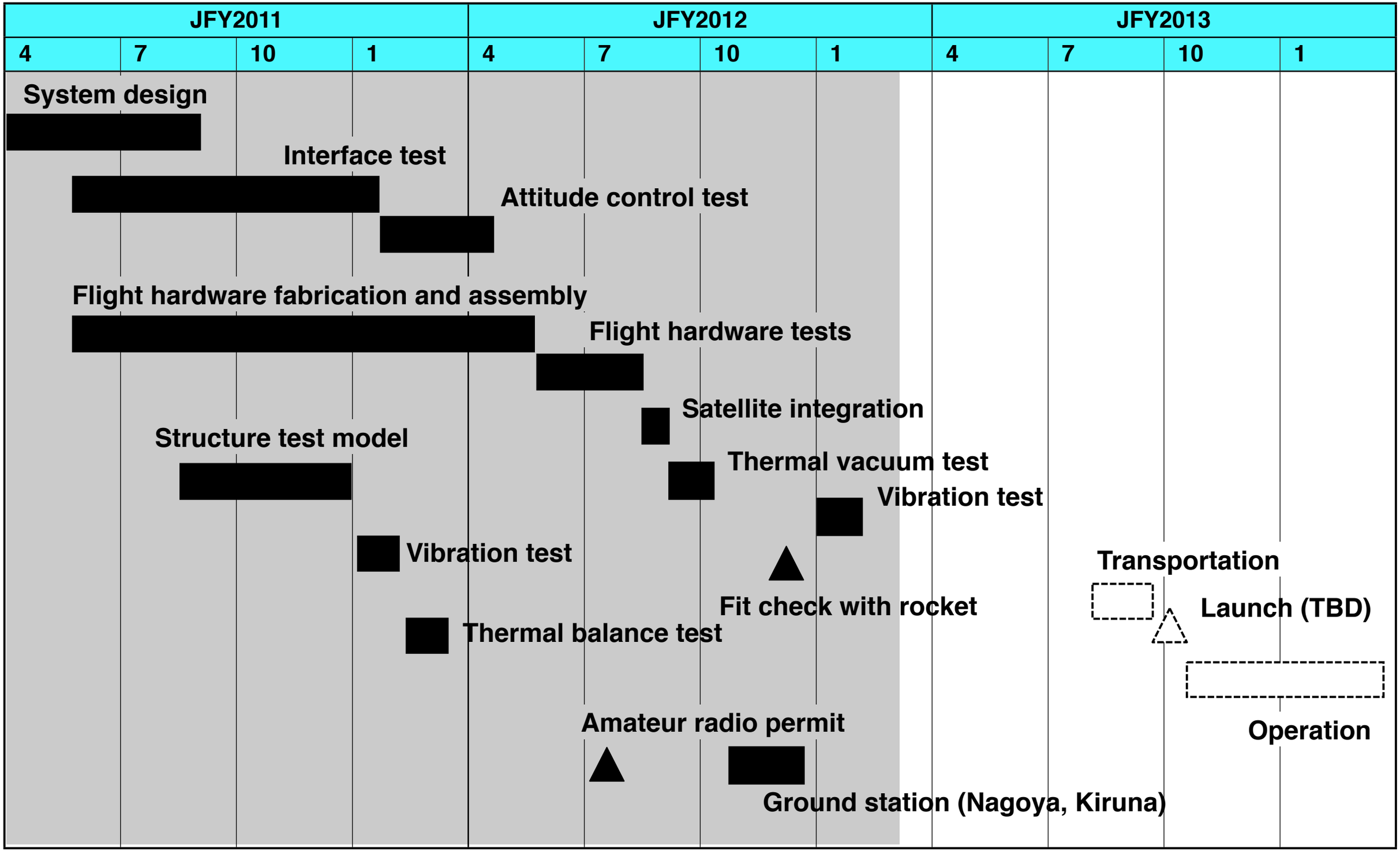
- Observation of space debris
  - Test observation of space debris around the satellite orbit
  - Plan to build an original database of space debris if successful



- Messaging service for amateur radio
  - Make use of amateur radio equipment for communications when not used



Development Timeline



Development Timeline

JFY2011				JFY2012				JFY2013			
4	7	10	1	4	7	10	1	4	7	10	1

System design

Interface test

Attitude control test

Flight hardware fabrication and assembly

Flight hardware tests

Satellite integration

Structure test model

Thermal vacuum test

Vibration test

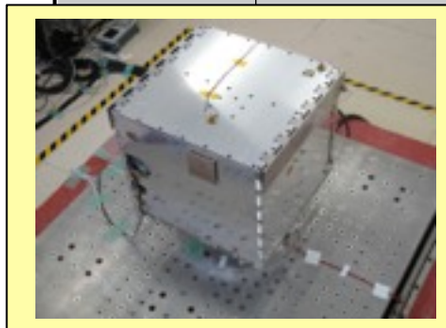
Vibration test

Transportation

Fit check with rocket

Launch (TBD)

Thermal balance test



Amateur radio permit

Operation

Ground station (Nagoya, Kiruna)

Development Timeline

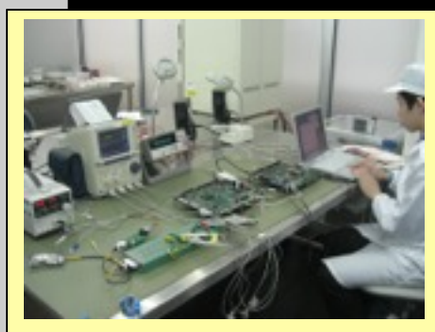
JFY2011				JFY2012				JFY2013			
4	7	10	1	4	7	10	1	4	7	10	1

System design

Interface test

Attitude control test

Flight hardware fabrication and assembly



Flight hardware tests

Satellite integration

Thermal vacuum test

Vibration test

ration test

Transportation

Fit check with rocket

Launch (TBD)

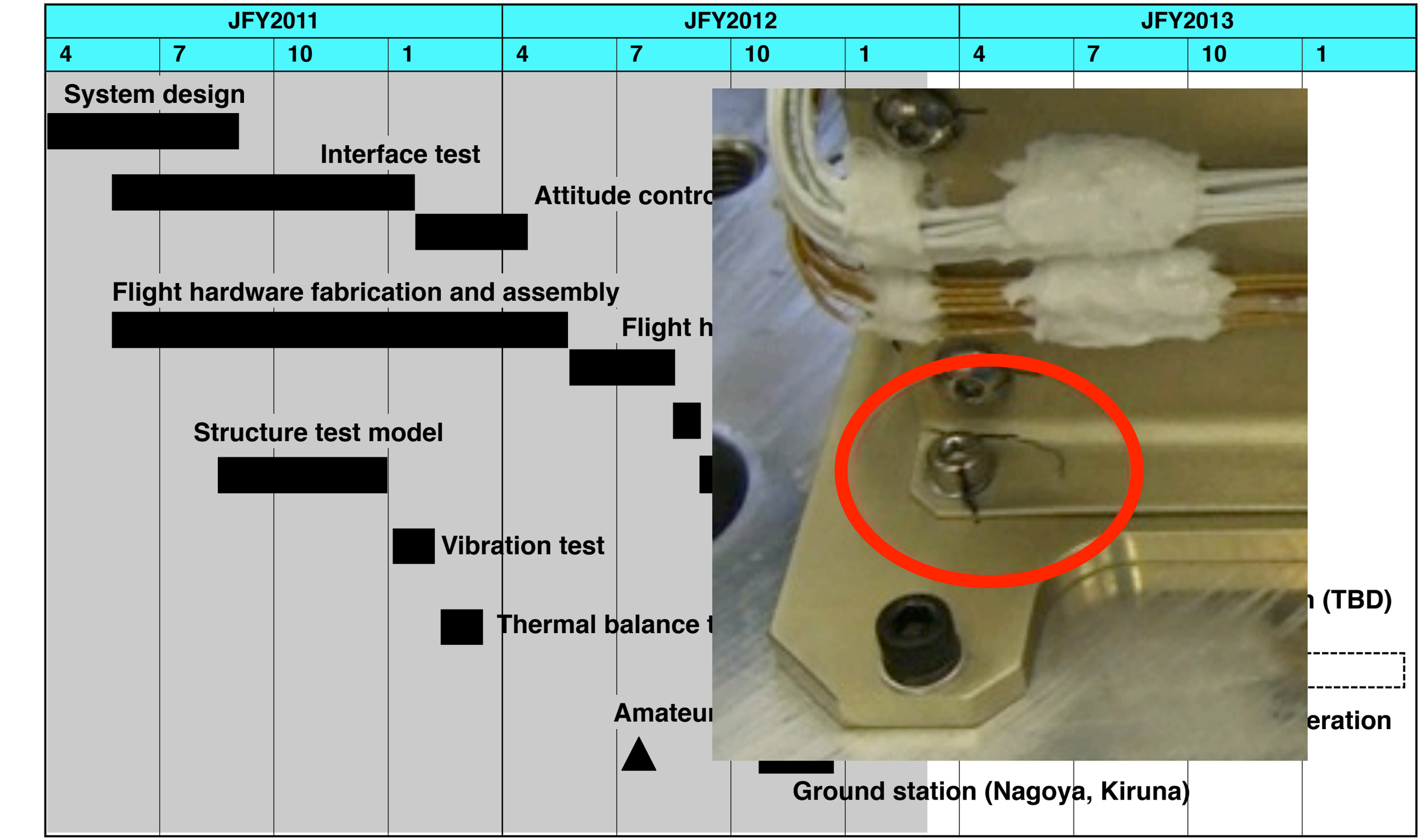
Thermal balance test

Operation

Amateur radio permit

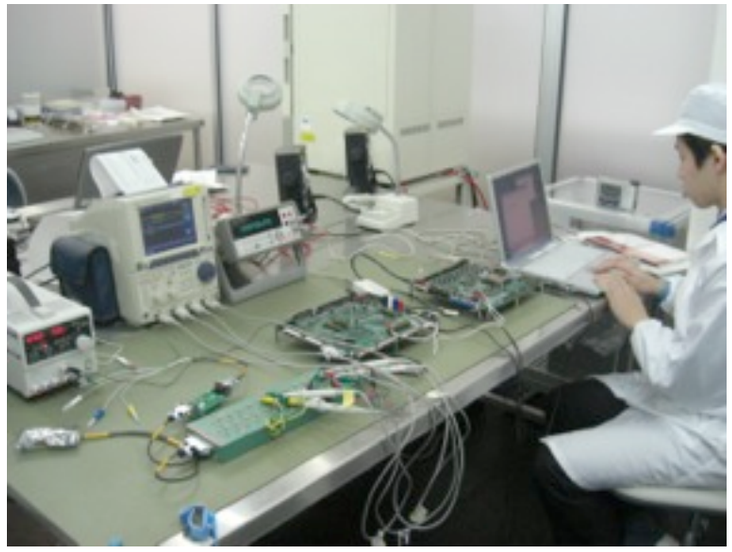
Ground station (Nagoya, Kiruna)

Development Timeline

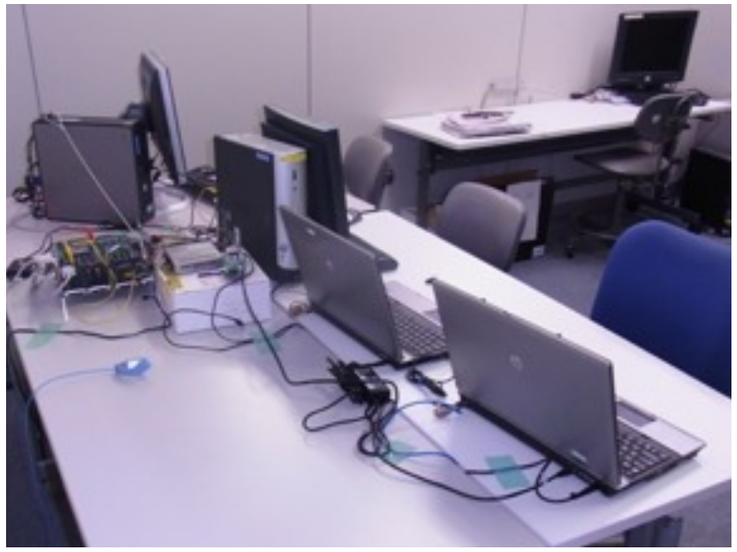


Picture Gallery

Interface test

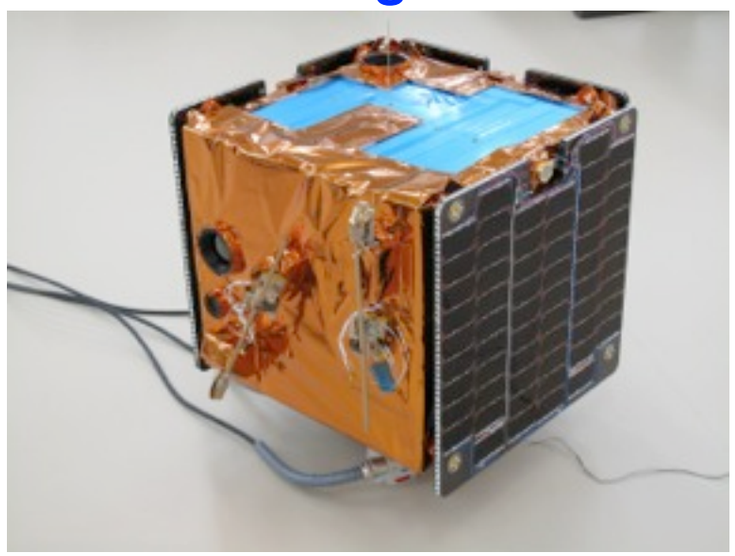


Attitude control system

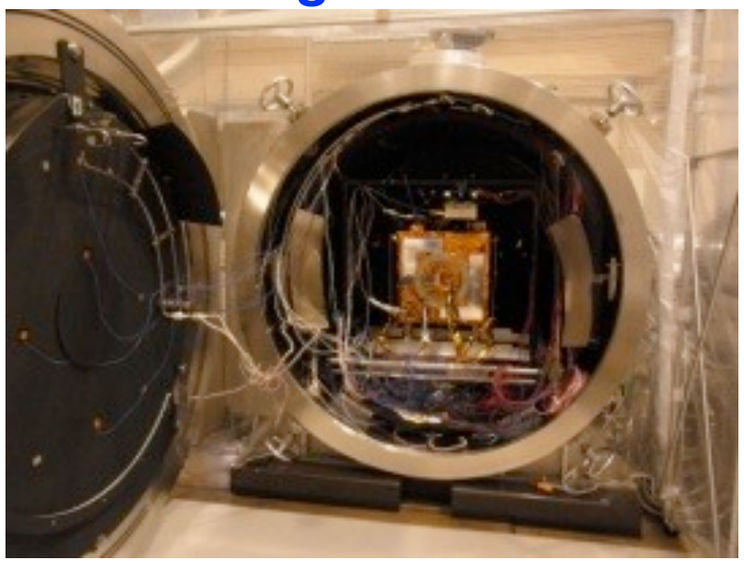


Integration test of flight hardware

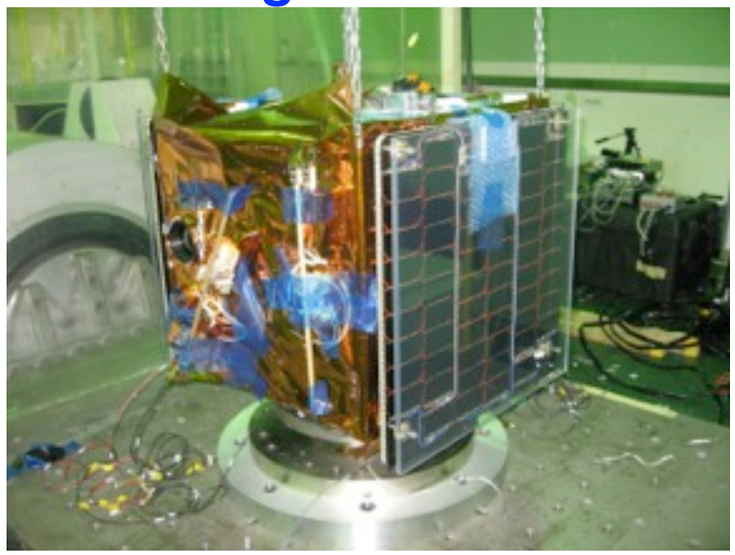
Satellite flight model



Thermal vacuum test of flight model

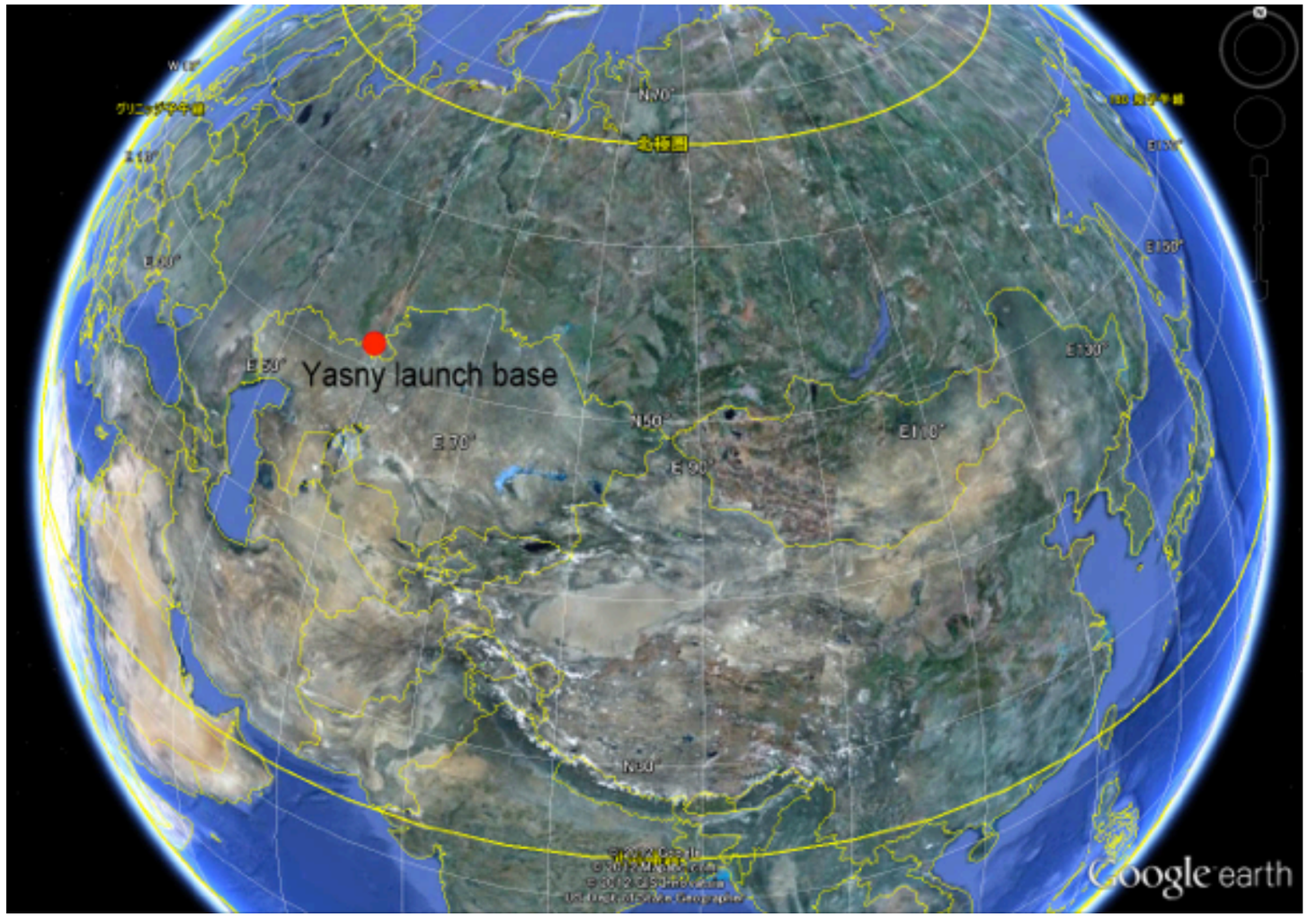


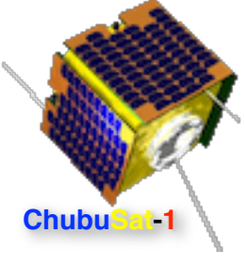
Vibration test of flight model



Launch Vehicle

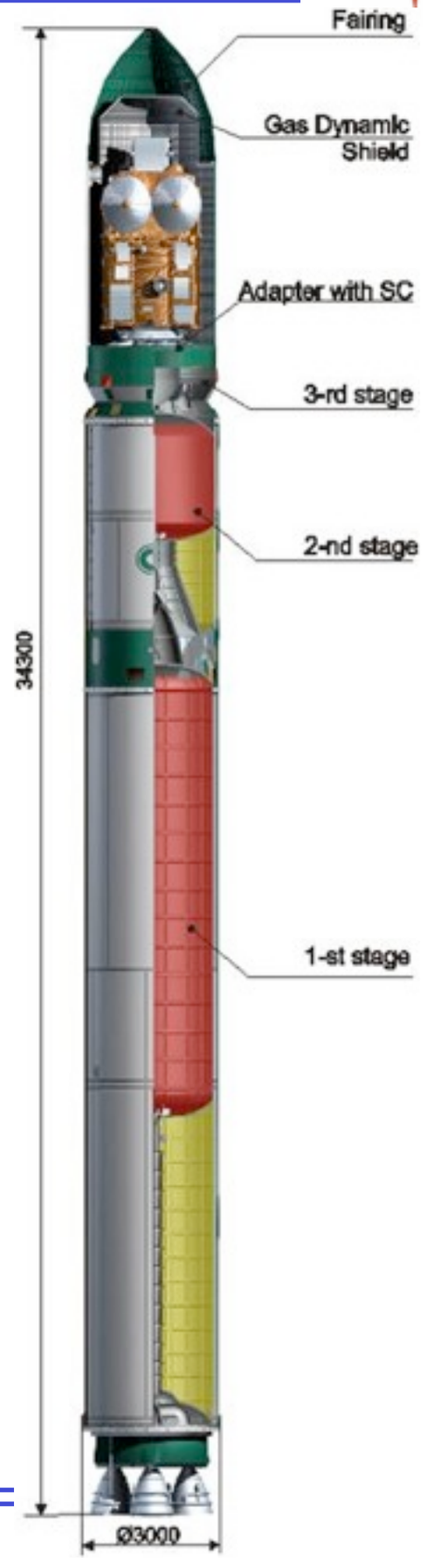
- Dnieper (Russia)
  - Civilian use of Russian strategic missile SS-18 operated by Cosmotras
  - 17 successful out of 18 launch since the first launch in 1999
  - Highly reliable, precise orbit
- Launched from Yasny launch base





Dnieper Rocket

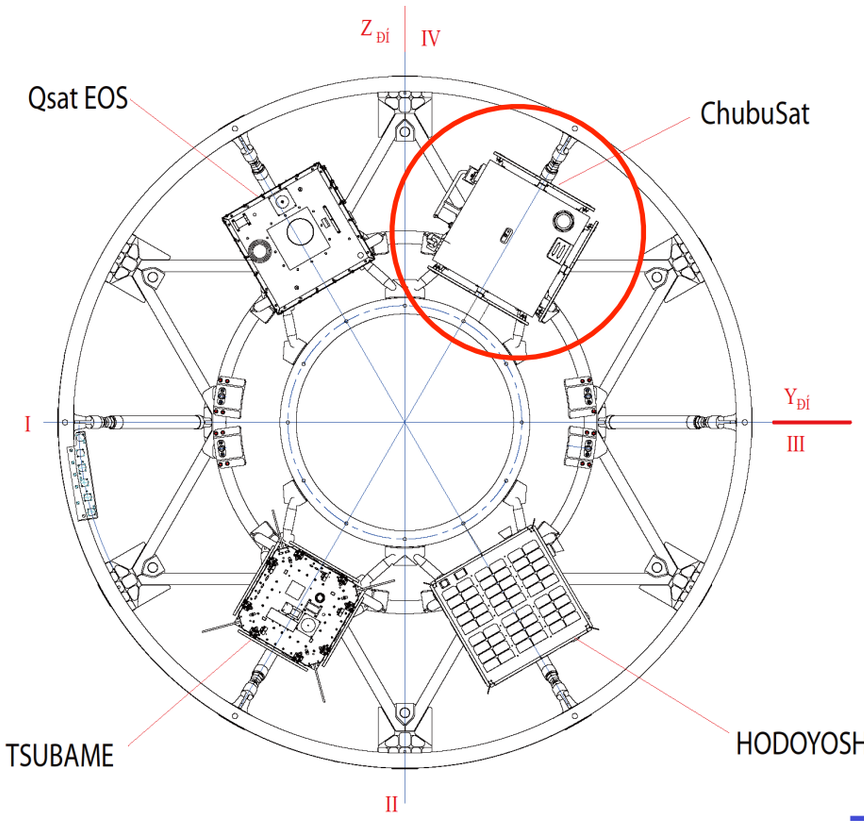
- Specifications
  - 3 stages
    - First and second stages same as SS-18 ICBM
    - Software modification for the third stage
  - Mass: 210 ton
  - Launch success rate: 97%

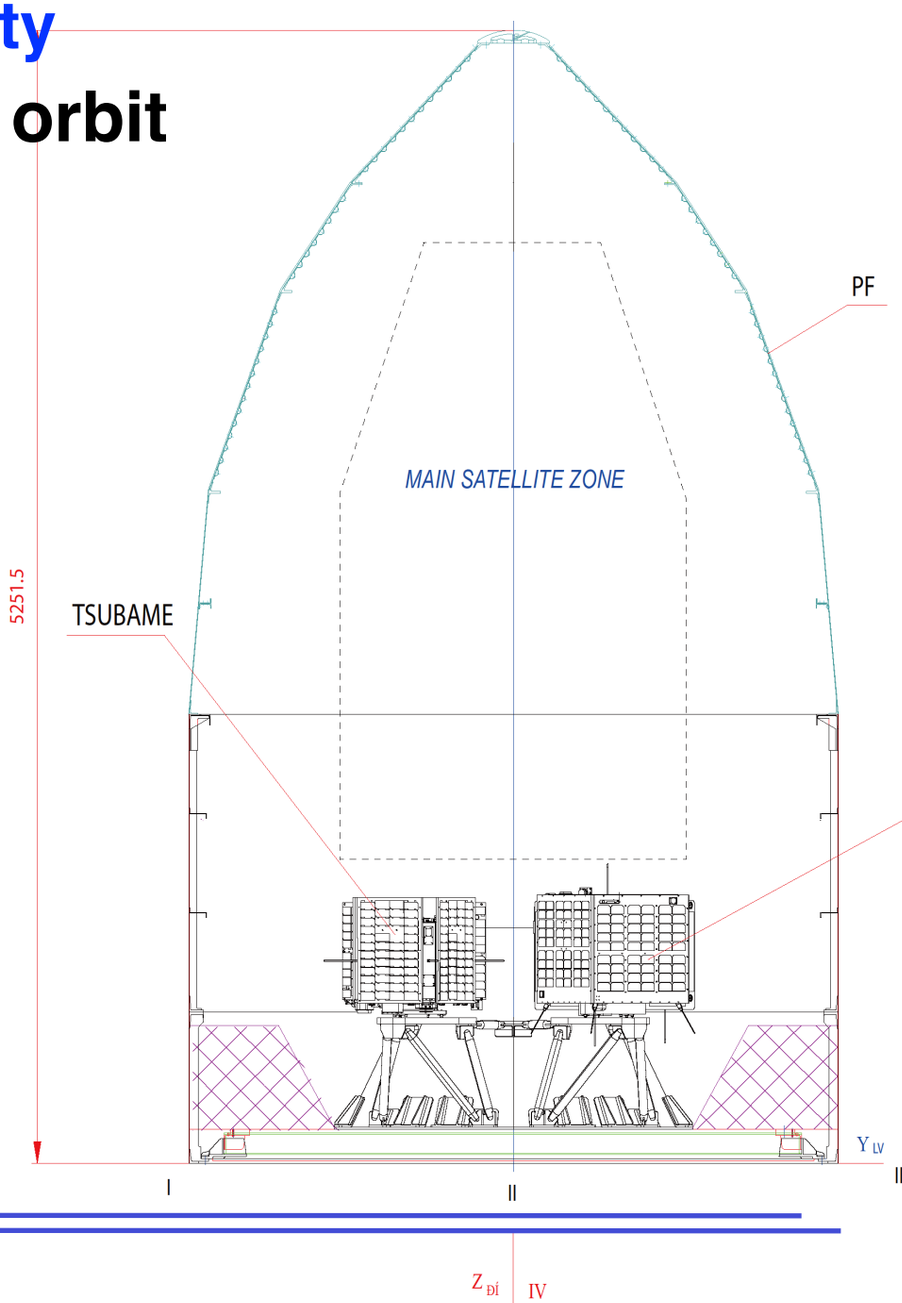


（コスモトラス社提供）

Piggyback Payload Launch

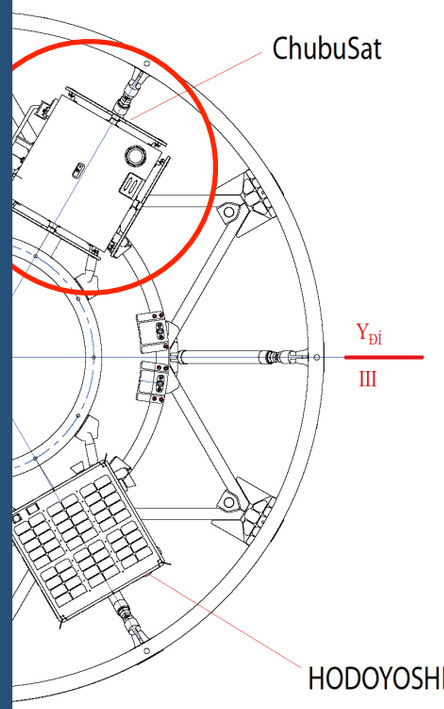
- Cluster launch (launch multiple satellites at the same time)
  - Next generation space System Technology Research Association (NESTRA)
  - Hodoyoshi-1 by University of Tokyo, TSUBAME by Tokyo Institute of Technology, Qsat-EOS by Kyushu University
- Orbit: 500 km – 600 km sun-synchronous orbit
  - 90 minutes per orbit

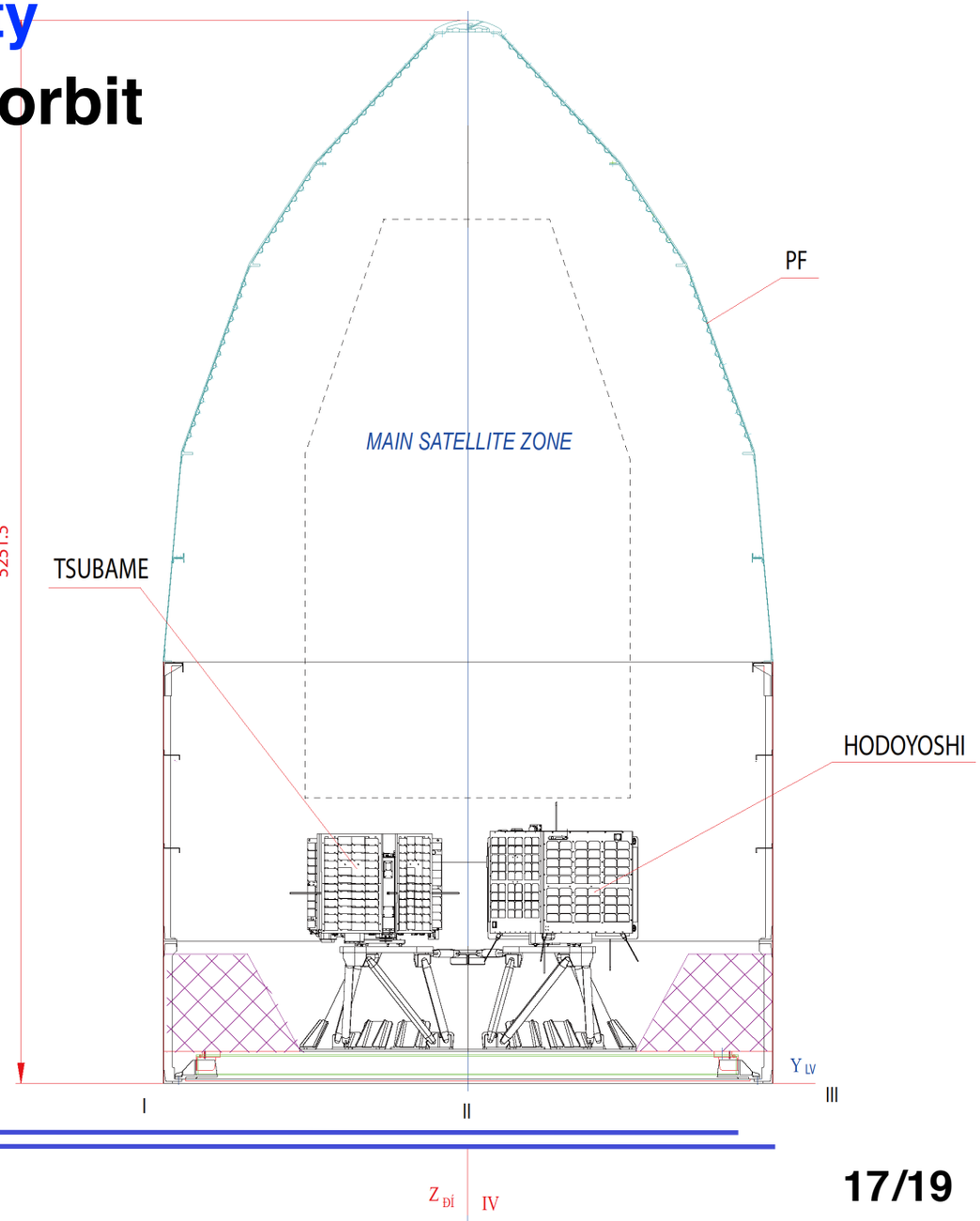


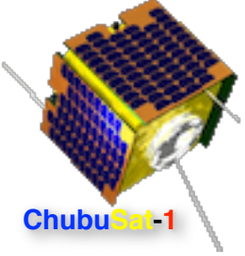


Piggyback Payload Launch

- **Cluster launch (launch multiple satellites at the same time)**
  - **Next generation space System Technology Research Association (NESTRA)**
  - **Hodoyoshi-1 by University of Tokyo, TSUBAME by Tokyo Institute of Technology, Qsat-EOS by Kyushu University**
- **Orbit: 500 km – 600 km sun-synchronous orbit**
  - **90 minutes per orbit**

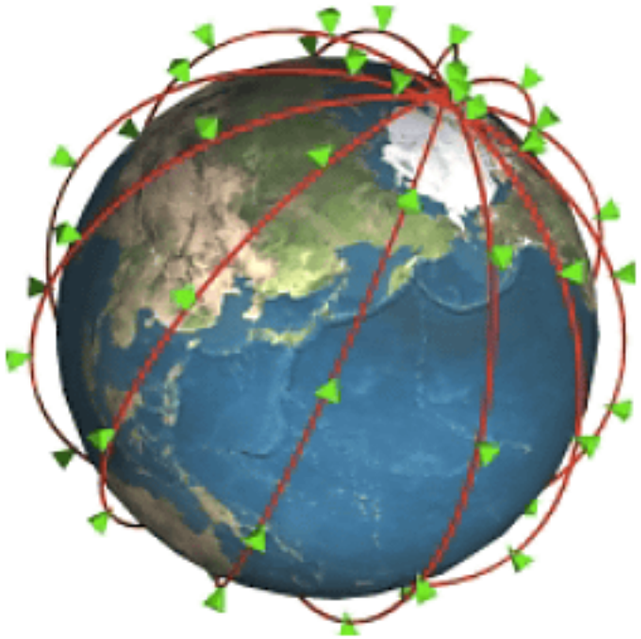


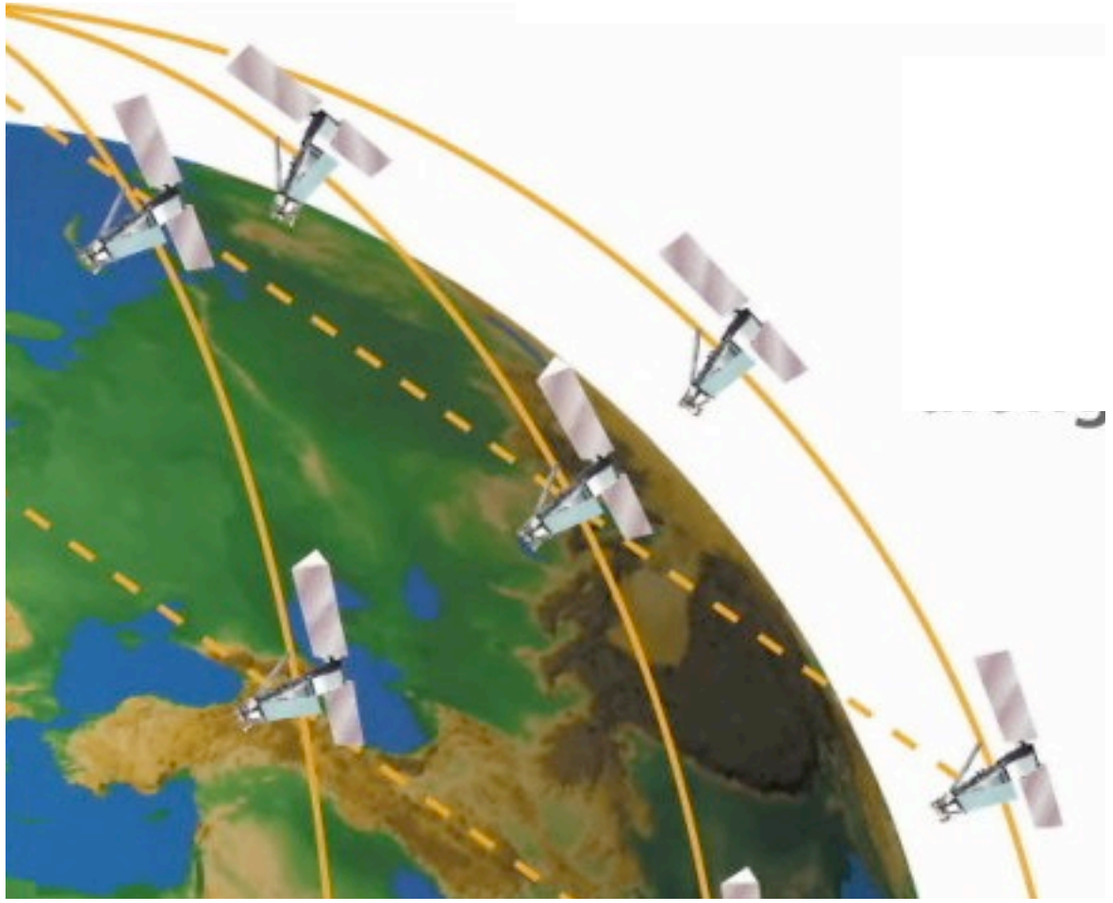


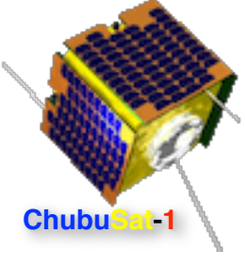


Communication Microsatellites

- **Example: Iridium**
  - **Complete coverage of entire Earth by 66 satellites**
  - **Huge initial cost hurts profitability**
  - **Learn from failures**
- **Microsatellites reduce initial cost by large factors**
  - **Improved profitability**
  - **Expand use other than satellite phone**
- **Common services world-wide**







Summary

- **ChubuSat-1 is ready for launch**
  - **Developed by industry-academic cooperation**
  - **Low cost by miniaturization, optimization and standardization**
  - **Aim for expansion of civilian space utilizations**

- **Business prospects**
  - **On-orbit tests of advanced technologies for large satellites**
  - **Expansion of market for satellite services**
  - **Working with Chubu branch of Ministry of Economy, Trade and Industry**
    - **Seminar for commercial use of microsatellites (2013/01/31)**
    - **Chubu region is selected as “Asia No.1 special district for aerospace industry cluster”**