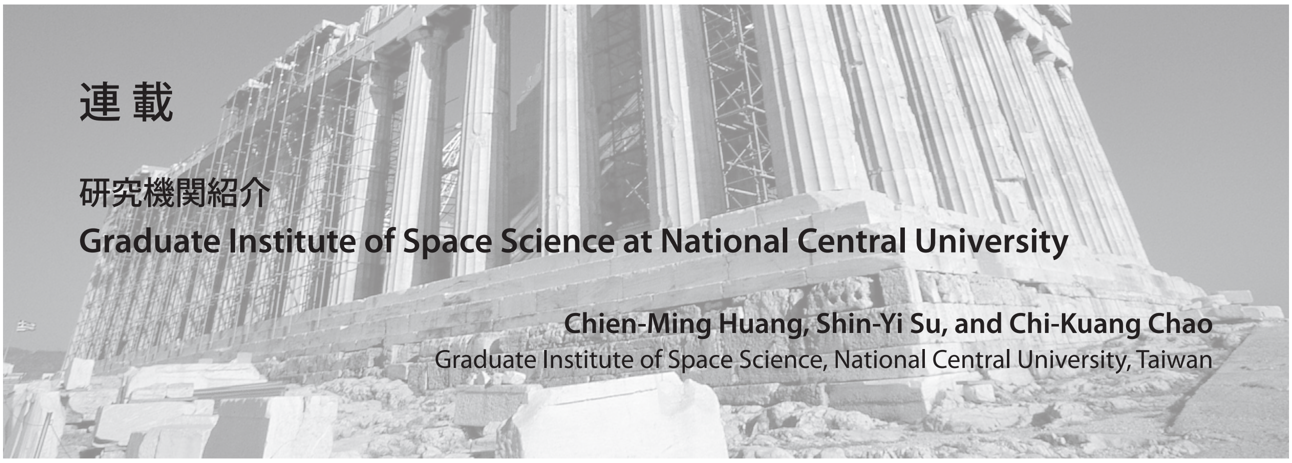

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研究機関紹介

Graduate Institute of Space Science at National Central University

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Director of the Institute of Space Science, Prof. Chien-Ming Huang

In 1990, the Ministry of Education of the Republic of China at Taiwan granted the permission to establish the Graduate Institute of Space Science (ISS) at the National Central University (NCU) to offer the Master of Science program. The mission of ISS is to meet the national need of introducing then the new branch of inter-discipline science, space science and technology, after 30-year endeavor in the space exploration and research since the launch of first man-made satellite "Sputnik" in 1958. In 1993, ISS began to offer the Ph.D. program. Currently, ISS is still the only institution in Taiwan to offer degrees in higher education in space science and technology with courses and laboratory teaching, cultivating the solar-terrestrial observation technology, building students' ability in data analysis and modeling skill. Finally, we also infuse independent and analytical thinking to students for their

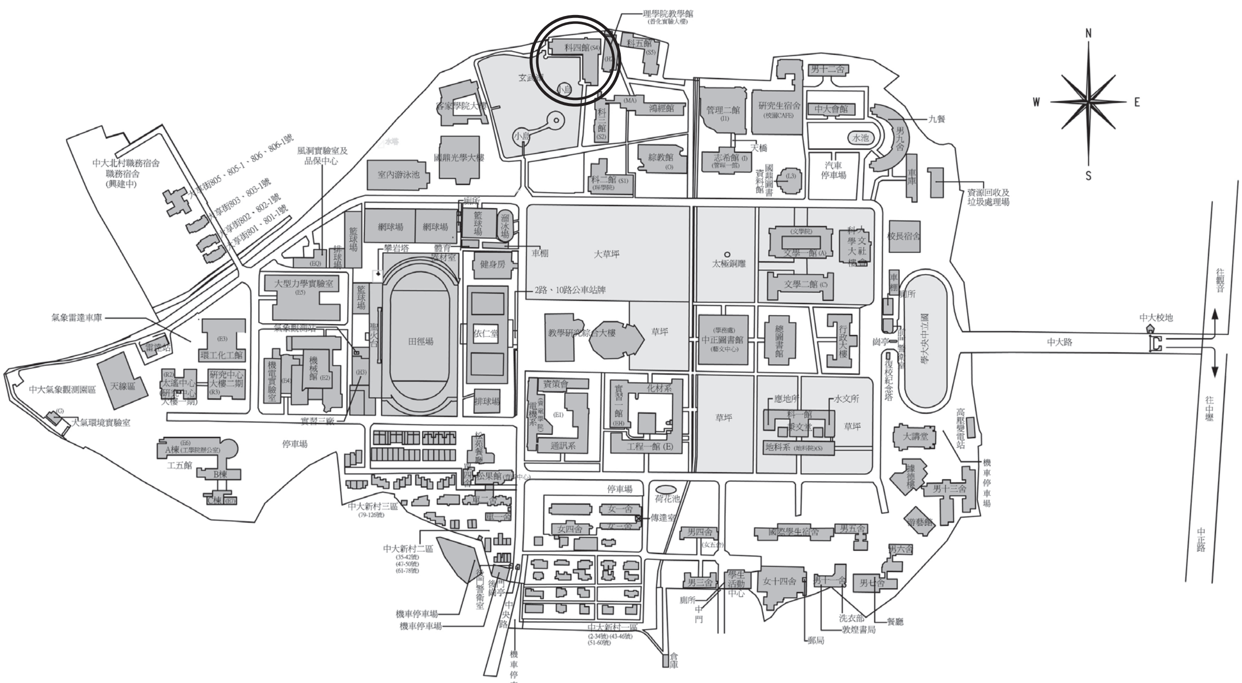

Figure 1: Campus map of NCU. ISS is marked in dual circles in the map.

future contribution to meet the national needs.

ISS is now affiliated with the Collage of Earth Science in NCU. In fact, when the National Central University was first re-established its campus in Taiwan in 1960, it had only one department, the institute of geophysics to teach the graduate courses in geophysics. As NCU moved to the current campus in Chung-Li in 1968 (see Figure 1), the courses in space science was taught within the group of upper atmospheric

Figure 2: Graduate Institute of Space Science is located on the 8-th floor and one half of the 9-th floor in Science Building IV.

physics in the Department of Atmospheric Physics. Then in 1990, the group branched out as the Graduate Institute of Space Science to offer the graduate degrees and administrate the space science group in the undergraduate study in the Department of Atmospheric Science. Currently ISS is located on the 8-th floor and one half of the 9-th floor of the Science Building IV (see Figure 2). So far (as of 2012) there are 397 students graduated with the MS degree and 54 students with the Ph.D. degree. Many of them are working in the universities in Taiwan and abroad to continue their pursuance of acquiring more knowledge in space science and technology, as well as educating younger generation.

Currently the Institute has a full-time faculty member of 7 professors, 3 associate professors, and 4 assistant professors. In addition, there are 6 professors and 2 associate professors in the joint appointment with other institutions such as Center for Space and Remote Sensing Research at NCU, and Academia Sinica in Taipei. The teaching and research topics engaged by the faculty members can be roughly grouped into three groups:

- Heliosphere, Magnetosphere, and Solar-Terrestrial Relationship.

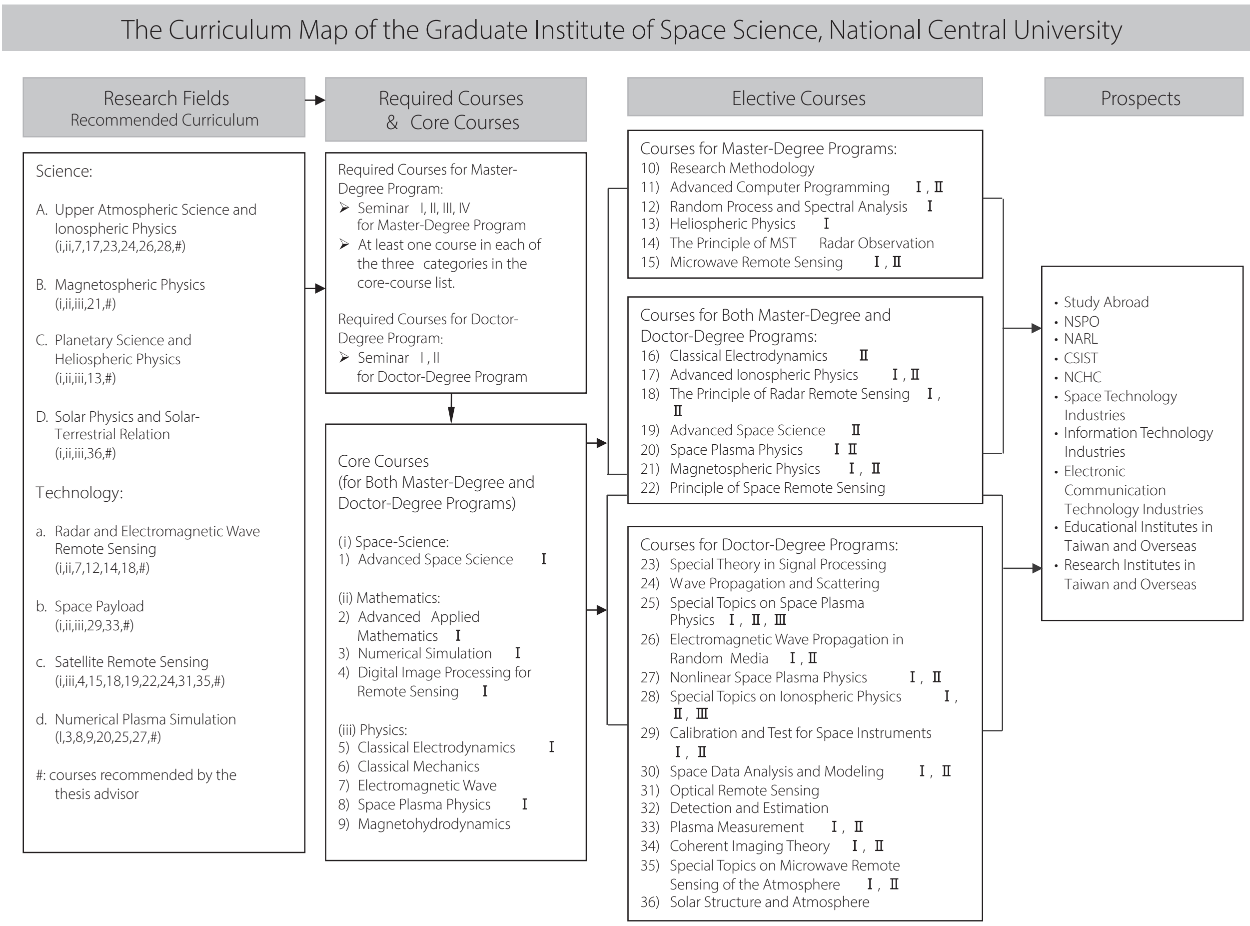

Figure 3: A curriculum map for ISS students.

- Ionosphere and Radar Probing of Ionosphere and Atmosphere.
- Remote Sensing Science of Earth and its Environment.

For students to join professors' research program, they are encouraged to take courses with emphasis on

- Space Plasma Physics and Space Physics.
- Ionospheric Physics.
- Radar Science.
- Space Payload Technology.
- Remote Sensing Science.

As the courses of Remote Sensing Science are taught at the Center of Space and Remote Sensing Research, we shall not dwell on this particular field further. Interested readers are referred to the website http://www.csrsr.ncu.edu.tw/ for further information. For students taking courses in "Space Plasma Physics and Space Physics", "Ionospheric Physics", and "Radar Science", the basic training is course taking with aid of data acquisition and analyses, phenomenological modeling of observations or mathematical simulation, and theoretical interpretation of observational data. To help students in electing courses and planning their career, a curriculum map is setup to guide students as seen in the Figure 3.

Professors, and MS and Ph.D. students as well as Post Doctoral Fellows together, have also indulged in research activities in their respective fields of expertise and publishing world-class papers. A few of researching results are briefly cited in the followings.

The solar active region such as high velocity event near a sunspot, the driving mechanism of coronal mass ejections has been studied and published (Lin et al., 2006, 2010). The Kelvin-Helmholtz instability characteristics of the magnetopause structure has been studied with MHD and Vlasov code (Lai and Lyu, 2008, 2009). The characteristics of MHD waves, fire-hose and mirror instabilities in anisotropic plasmas have been studied and published (Hau and Wang, 2007). The space-borne data analyses have yielded significant results in studying the earthward fast flow in the plasma sheet, and the understanding of uneven compression of the Earth's magnetic fields by shocked solar wind (Shue et al., 2007, 2010). As for the ionospheric study with ionosonde, GPS, and FORMOSAT-3/COSMIC data, the most noted results are observations of the ionospheric pre-seismic signatures and disturbances related to the Tohoku earthquake, Wenchuan and Pingtung doublet earthquake, and Sumatra-Andaman earthquake (Liu et al., 2010; 2011; 2011). In addition, the Taiwanese FORMOSAT-3/COSMIC data has yielded a new result about the Weddell Sea Anomaly (Lin and Liu et al., 2009). The ROCSAT-1 (FORMOSAT-1) data has been studied to have a better understanding of the pre-sunrise plasma heating in the low-to mid latitude topside ionosphere (Chao et al., 2010). Using Chung-Li 52 MHz VHF radar observations, a better understanding of the E-region irregularities has been advanced (Chu et al., 2007; 2009). The typhoon wind structure modification over Taiwan has also been studied with the wind profile (Pan et al., 2010). Finally, many ionospheric positive storm phases at the magnetic equator near sunset have been investigated and published (Huang et al., 2010).

Besides the annual funds of education supported by the Ministry of Education through NCU, professors have also been supported by grants from many other institutions, mainly the National Science Council. On the average, a total of ~31,000,000 TWD (~1 M in USD) research funds are received by the Institute yearly.

Major Laboratories in ISS

Under these funding supports, many laboratories have been setup by faculty members to support their research activities and to meet the teaching needs. Here we describe a few laboratories in the following:

- High Speed Computing Laboratory: The lab provides high-performance computing and network environment for students and faculty. The computer workstations are located inside a firewall to reduce interference from Internet traffic. The Center also has a full size plotter, and many servers, such as domain name server, web server, mail server, file server, and software license server. Full size plotter allows students and faculty members to produce a full size poster for presentation in workshops.
- Wave Propagation Laboratory: The lab's major facilities are the Chung-Li 52 MHz VHF radar, and the 30 MHz bistatic radar for detecting E- and F-region irregularities and atmospheric clear air turbulences. A 19.5 GHz microwave radiometer together with a 19.5 GHz ground radar system is used to measure the atmospheric humidity contents for assessing the wave attenuation.
- Ionospheric Radio Science Laboratory: The main facilities are Ionosonde, Doppler sonder, Infrasonde, etc. The lab also collects lots of FORMOSAT-3/COSMIC GOX and TIP data for study the space weather effects.
- Satellite Payload Development Laboratory: The lab has been setup to fabricate a precision fluxgate magnetometer for future payload. A Helmholtz cage is constructed to test the accuracy of the magnetometer. The lab also develops a photometer to measure airglow and a Langmuir probe for electron density and temperature.
- Office of Taiwan THEMIS: The mission was conducted by Dr. V. Angelopoulos to focus on magentospheric substorms and geomagnetic storms. The office in Taiwan participates the science study and have the following research topics as
    - A systematic study of the substorm growth and expan-

sion phases: multiple observations
  - Source and transport process for the ring current evolution during geomagnetic storms
  - Theoretical and simulation study of multiple-scale nonlinear process during the growth phase, onset, and expansion phase of magnetospheric substorms
- EM Wave Information Laboratory
- Space Payload Laboratory – Core Facilities and Learning Facilities

Space Payload Laboratory

In recent year, major effort has been undertaken by the institute to develop the space payload technology. The main focus is to design and fabricate space payload to participate in Taiwan's latest space program of FORMOSAT-5 (scheduled to launch in 2015), FORMOSAT-7 (in 2018), and Sounding Rocket 2 (was launched on 10/24/2001), 3 (on 12/24/2003), 5 (on 01/08/2004), 7 (on 05/05/2010), and 9 (scheduled to launch in August 2013). Chi-Kuang Chao, an Associate Professor at ISS, in collaboration with Professor S. Minami at Osaka City University, Japan, is the main investigator for this latest endeavor to meet the institute's goal of enhancing the space science education with space technology. The Space Payload Laboratory was established in 2006 by Professor Chao who undertakes this major effort based on his participation in Taiwan's first space program of launching the Taiwanese first spacecraft, the ROCSAT-1 satellite in 1999. Adopting the heritage of ROCSAT-1 payload, Ionospheric Plasma and Electrodynamics Instrument, (IPEI, see Figure 4), an instrument to measure the ion density, drift velocities, temperature, and composition, this particular laboratory was setup to educate students with latest space technology, and to design and fabricate space payload for future Taiwanese space program.

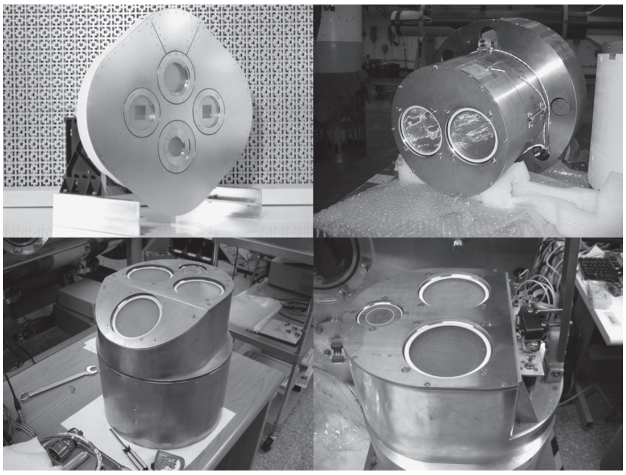

Figure 4: The space payloads, IPEI onboard ROCSAT-1 (top left), Ion Probe onboard SR-V (top right), Plasma Probe onboard SR-VII (bottom left), and Space Plasma Sensor Package onboard SR-IX (bottom right).

The major milestones of such endeavor are

- Test environment for space payloads: fundamental tests for space environments are provided for comprehensive tests during payload fabrication. Currently, SPL can provide the following environmental tests:
  - Plasma release test: A space plasma simulation chamber (see Figure 5) was setup to generate ionospheric-like plasma in a cylindrical space of 1.5 m long and 0.7 m inner diameter. The design and order of the chamber was carried out in collaboration with Professor S. Minami of Osaka City University. The pressure can be down to 10-6 torr and normal operation around 10-4 torr under a mass flow meter/controller within 0.02 to 10 sccm (see Figure 6). Remaining gases can be identified between 1 and 100 amu with a residual gas analyzer. Plasma generated in the chamber with density between 10^3 and 10^6 # cm^{-3} and temperature between 1,000 K and 2,000 K. A turn table can be used to measure the sensor in different rotation angles. The chamber has been used to test and calibrate the Taiwan-Russia microsatellite (ESEMS) payload, an electron temperature probe, the plasma

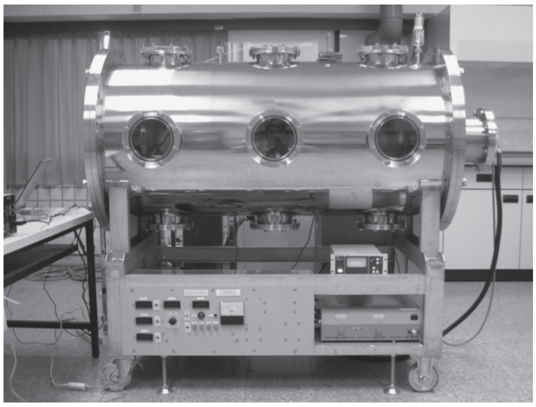

Figure 5: Space Plasma Simulation Chamber at SPL.

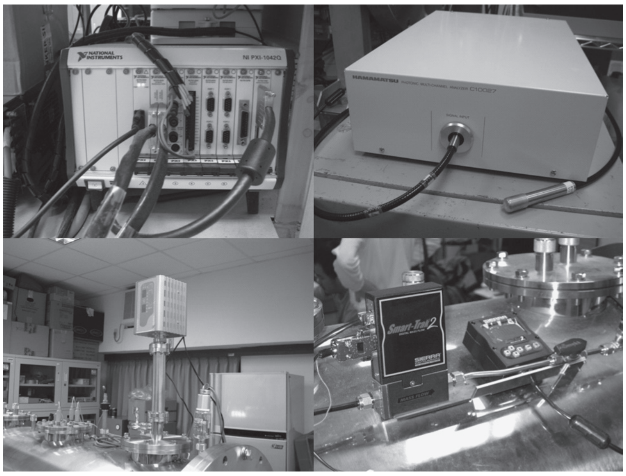

Figure 6: Monitoring system for SPSC.

probe for SR-VII, ion probe for micro-satellite of Moscow Aeronautic Institute (MAI), and the space plasma sensor package for SR-IX.

- Thermal vacuum test: The space plasma simulation chamber is used to provide a vacuum condition for the thermal vacuum test. Temptronics TPO4300A ThermoStream is a thermal source (see Figure 7) to make heat transfer via dry compressed air. The compressed air flows through a spiral copper tube welding with a cooper plate to raise/lower temperature of the device under test on the plate (see Figure 8). Currently, the vacuum level can reach to 10^{-6} torr and the temperature range can be maintained between -40 ºC and +80 ºC. Temperature cycling test can also be performed in a front-load chamber via the same thermal source.
- Vibration test: An EMIC vibration test system (see Figure 9), F-06000BM, is capable to perform sine and random vibration tests for most payloads on sounding rockets or

Figure 7: A thermal source for thermal vacuum test and temperature cycling test.

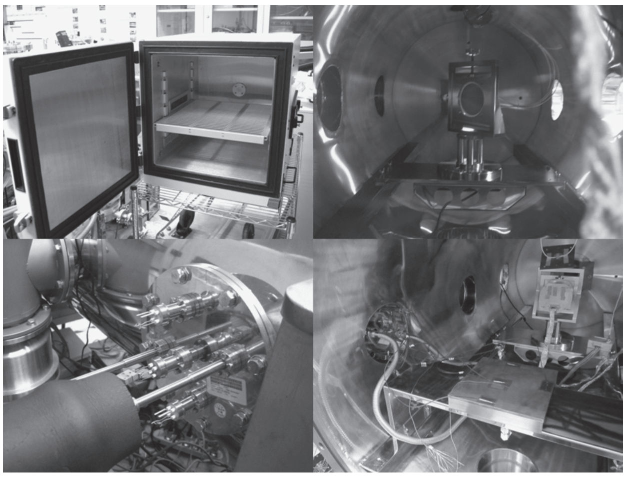

Figure 8: A front-load chamber for temperature cycling test (top left), a turn table for rotation test (top right), feedthroughs for gases and thermal couples (bottom left), and thermal plate for thermal vacuum test (bottom right).

Figure 9: Vibration test system for sine and random vibration.

satellites. The peak exciting force is 6.0 kN, the maximum load 60 kg, and the frequency range from DC to 3,500 Hz.

- In-house PCB fabrication: Rapid PCB prototyping of space payloads is possible to use the following facilities (see Figure 10 and 11), like circuit board plotter, through-hole conductivity/plating, multilayer prototyping, screen printing and solder-resist masks, SMT solder paste printer, pick and place assembly system, lead-free reflow oven, etc. In general, a double-layer A4-size PCB can be fabricated and installed with components in one day. The ion probe for Microsatellite MAI and aspectmeter for SR-VIII are fabricated in the lab.
- Infrastructure for design and analysis: SPL provides the following hardware and software to design and verification of concept:
  - Hardware: 5 sets of NI ELVIS, ELVIS II+, sb-RIO, Xilinx Spartran-3AN and CoolRunner-II starter kits, 2 sets of NI CompactRIO and NI PXI chassis with measurement and

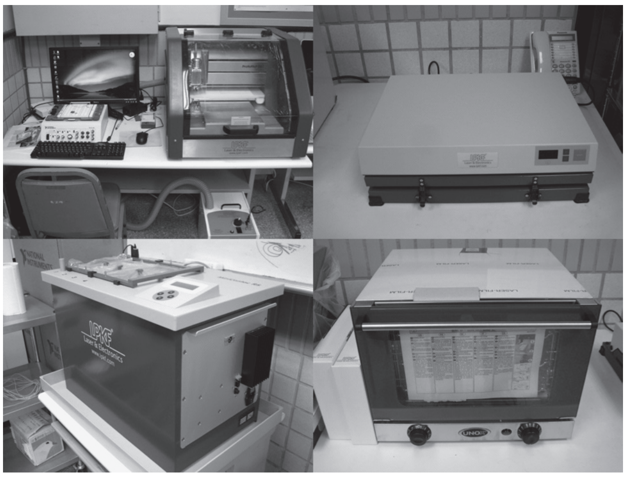

Figure 10: PCB circuit plotter (top left), UV exposer (top right), through-hole plating (bottom left), and hot air oven for solder resist mask (bottom right).

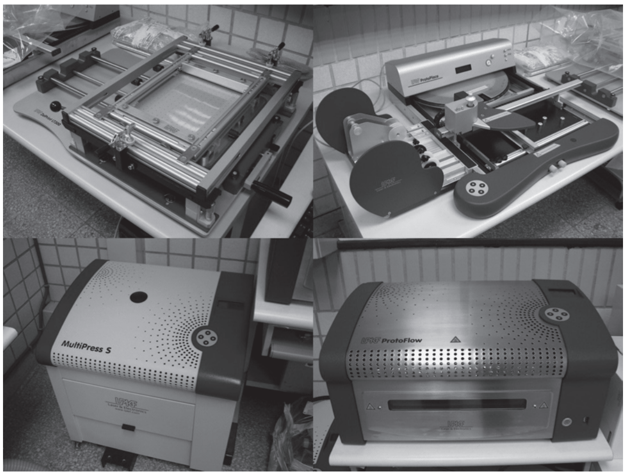

Figure 11: SMT solder past printer (top left), pick and place assembly system (top right), multilayer prototyping presser (bottom left), and lead-free reflow oven (bottom right).

RF modules, one NI CompactDAQ and USB DAQ, Keithley pico-ammeter, etc.

- Software: Ashlar-Vellum Cobalt and Graphite charitable version (1-seat standalone license, mechanical CAD), Dassault Systèmes SolidWorks Education Edition (30-seat floating license, mechanical CAD and simulation), Intel Composer XE for Windows 2013 (2-seatfloating license, used with SCINDA), MathWorks MATLAB (25-seat floating license for all platform and one-seat standalone license for Mac OS X, data analysis), MCS Software Academic FEA Bundle (5-seat floating license, thermal analysis), NI Academic Site License – Department Teaching License (unlimited floating license, DAQ, embedded system, and circuit design and layout), etc.

In conclusion, it is believed that the Graduate Institute of Space Science at the National Central University has fulfilled its mission goal of educating and providing the latest space science and technology to the young generation. The Institute will further expand and strengthen its capacity to be a leader in the field of space science and technology in Taiwan. It will strive to be in the same category of leading institutions in space science and technology in the world.