# ***重啟 2020：高空氣球艙計劃***

# ***Mission: Reconnect 2020***

## 外展活動計劃書 Outreach Proposal


**摘要**

COVID-19 疫情讓世界丟失了 2020。全球進入封鎖狀態，各界頓時中斷國際與國內交流。封鎖的日子沉重打擊了：國際科研合作、大學生學術訓練、中小學教育與成長。“Mission: Reconnect 2020 【重啟 2020】”是一項跨學界、跨國界、跨天際之合作計劃，象徵我們重啟【地球村】之決心， 雄偉地展開 2021 新未來。同時也藉此計劃擴展大馬與台灣年輕人的視野和雄心壯志。此計劃任務包含:（一)由國立陽明交通大學(NYCU)陳竺博淵教授之 ASARe Lab 與賴錦文教授之 AeroTech Lab 主導, 並和馬來西亞 USM 理科大學合作設計，製作與飛行≥1 架【氣球艙】至太空邊沿。(二) 讓【氣球艙】搭載科研儀器、大學工程品和中學試、藝術等作品, 展開一項跨界的【希望】旅途。(三) 由台灣牽頭，邀請馬來西亞、美國等多國合作參與。**此書為【重啟 2020】邀請基隆市中學參與飛行任務之外展活動提議。**



**Abstract**

Our world lost the year 2020 to the COVID-19 pandemic. Global and local interactions came to a halt when communities entered isolations to curb transmission of COVID-19. In addition to its impact on the wider community, the year under isolation severely impacted research collaboration, in-person college training, and elementary to high school education. “***Mission: Reconnect 2020***” is a cross-academia, cross-border and cross-skyline socio-scientific mission symbolizing our resolve to reverse the isolation of 2020, to blaze into 2021 with the bold will-power to reconnect everyone. This project is comprised of:

(i) 1-2 flights on a high-altitude balloon (HAB) to the edge-of-space, on missions led by the National Yang Ming Chiao Tung University (NYCU)’s Prof. Tan Zu Puayen’s ASARe Lab and Prof. Lua Kim-Boon’s Aero-Tech Lab, in collaboration with Universiti Sains Malaysia (USM).

(ii) Scientifically and symbolically profound payloads of “hope” on the balloon capsule, consisting of research instruments, college student engineering designs and participating school’s experiments or artistic expressions.

(iii) International collaborations headed by Taiwan, with partners from Malaysia and the U.S.

**This project proposal outlines our invitation for middle/high schools in Keelung City to participate in *Mission: Reconnect 2020*.**

## Introduction and International Motivation

The COVID-19 pandemic swept the world by surprise. Countries enacted varying degrees of lockdowns to curtail the pandemic, ranging from cancelling flights, to quarantining suspected persons, to enforcing lockdown of citizens within homes. **Aside for Taiwan**, which has remained a shining example of success in COVID-prevention, life in most countries have not returned to normal at the point of writing, which marks a full year of isolation-lifestyles.

The inability to exercise close contact between people in isolation has had noticeable impact on mental health, as well as practical livelihood. In the field of academia and education in which we operate, COVID lifestyle has three noticeable impacts around the world:

(i) At the research/graduate school level: The inability to participate in physical conferences and collaborations, as well as the inability to operate any research at all in countries with on-going lockdown.
(ii) At the college level: Many colleges in the world canceled class or moved to online lecturing during the most severe period of COVID-19. In the U.S., partial online-lecture remains the norm. These severely affected the quality of education and mental health related to lack of socializing for students who are just transitioning into their adulthood.
(iii) **At the elementary/middle school level:** Education naturally moved to home-schooling and online-learning. Any international travel and competitions are also canceled. Removal of these young students from their class and social environment has adverse effects. For the younger of these students, COVID lifestyle may also become an unhealthy impression they form regarding what's considered "normal" in the world. COVID lifestyle's long-term effects on these students are yet unknown.

Given the pandemic's severe impact, it is not an over-statement to claim: the world has lost a full year (2020) to COVID.


Fig. 1. Conceptual rendering of ***Mission: Reconnect 2020***.

**In response, "*Mission: Reconnect 2020*" is a cross-academia, cross-border and cross-skyline (i.e. near space) project combining research, education and outreach in one bold mission to symbolize reversal of the isolation lifestyle and depressed state left by 2020. To march into the post-pandemic era with our heads held high.** ***And who better to lead this mission than the leader in COVID-mitigation: Taiwan?***

The project (conceptual image in Fig. 1) consists of 1-2 flights on high-altitude balloons (HAB) engineered in Taiwan and launched from Malaysia to the edge-of-space (~25,000m). Led by NYCU's Prof. Tan Zu Puayen's Aerospace Systems and Aerodynamics Research Lab (ASARe Lab, 航太系統與流體力學實驗室), NYCU Prof. Lua Kim-Boon's Aero-Tech Lab and the University of Science Malaysia (USM), these flights of "hope" will tentatively carry payload capsules filled with research instruments, college student engineering designs and **elementary/middle school contributions (e.g. experiments, artworks etc.)**.

From this point of writing to the planned flight in August 2021, the preparatory process for ***Mission: Reconnect 2020*** will be driven by college students at NYCU and USM, who will be trained in the design and fabrication of balloon "spacecraft." Additionally, the student team will collaborate with Masters/Ph.D. students to fly scientifically-meaningful research payloads on the capsules. The cross-border nature of this project is expected to encourage closer working relationships between professors from different universities and countries who are participating in ***Mission: Reconnect 2020***.

**Last but not least, as part of *Mission: Reconnect 2020*'s efforts to "reconnect everyone", we would like to extend an invitation to the middle/high schools of your city to participate in this flight to the edge of space. Specifically, we propose carrying out half-day talks/interactions at selected schools to kick-off the activity, after which interested student groups will be taught how to design small experiments/payloads aimed at riding on our mission capsule. These payloads will be flown to ~25,000m in August 2021, and pending successful recovery, returned to your students for analysis and display.**

The overall mission, being one of cross-border and cross-academia, will advance science while also serving as a strong symbol to "reconnect 2020" and move towards a brighter 2021.

## Engineering and Mission Details

The general mission concept is illustrated via Fig. 2: a conic capsule that resembles reentry spacecraft vehicle will be engineered and fabricated at NYCU by college research students 大學部專題生 under the guidance of Prof. Tan Zu Puayen and Prof. Lua Kim-Boon, along with technical assistance from our USM collaborator who has numerous previous HAB experience. The capsule will be attached to a helium-filled HAB as illustrated, and released with flight approval in Malaysia. The capsule and HAB will subsequently rise above the height of Mount. Everest and typical airliner cruising altitudes, all the way to the stratosphere (~25,000m). Here, the sky will appear pitch black and the Earth's curvature may be visible. Cameras on the capsule will tentatively record images of student payloads against the inspiring Earth background. Livestream of video from the capsule may be possible, dependent upon the readiness of the transmission equipment. **Temperature outside will approach -50$^{o}$*C*, pressure to near-vacuum and radiation level increased**, presenting a unique harsh environment for which the student team will have to engineer the equipment and experiments.

At its highest point (~25,000m), the HAB will reach its maximum size and burst automatically, whereupon the capsule will enter a freefall. After gaining sufficient velocity, a descend parachute will be deployed and the capsule will descend back to Malaysia in a safe manner. GPS beacons on the capsule will assist in recovery of the vehicle after landing. **Though, as this is literally "rocket science", success is hard and not guaranteed.**

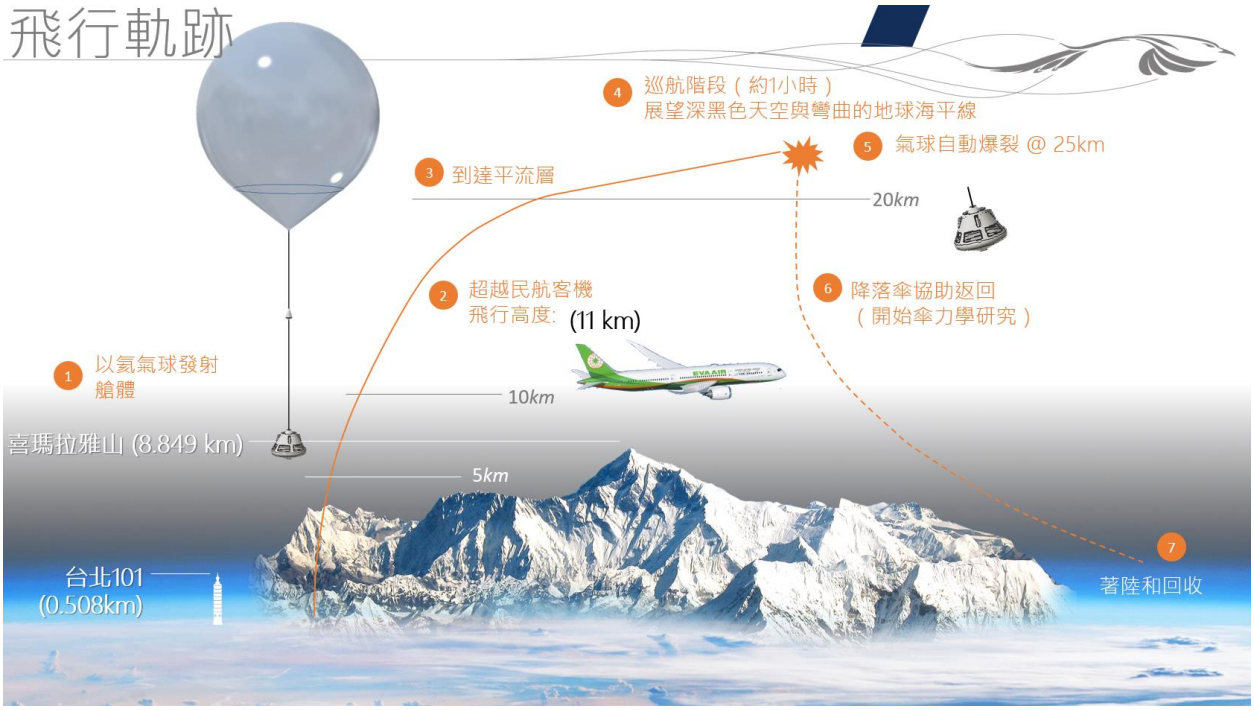


Fig. 2. Flight profile for ***Mission: Reconnect 2020***'s HAB capsule.

Preliminary design of the capsule is illustrated in Fig. 3, along with approximate timeline for the project. NYCU will engineer a new capsule resembling typical reentry spacecraft. The choice to employ a capsule shape also has the advantage that it will generate an aerodynamic pattern resembling real spacecraft on descent. The total system weight will be limited to 3kg, constraint by the balloon lifting capacity. Internal payload volume will consist of a 9U-cubesat format: $(10\times10\times10)cm^3 \times 9$. Notably, to accommodate landing impact, the bottom shell of the capsule is likely formed by light-weight shock-absorbing Styrofoam, which simultaneously acts as thermal isolation against the outside cold. Numerous windows may be installed around the capsule hull, such that payloads located inside have a direct view of space. E.g. an interior-mounted camera may take video of school student payload against the space background through the window to inspire space awareness.

As shown in the timeline of Fig. 3, two separate flights within days of each other are initially planned for this mission (subjected to change), such that more diverse payload can be sent and such that the probability of recovering at least one capsule is reasonable. The flights will take place on August 2021, assuming COVID lockdown and mandatory quarantines have been lifted. A back-up launch day will be set during the winter holiday (Dec 2021 or Jan 2022). The timeline of the remaining events leading up to and after the flight are as listed. Notably, we hope to begin conducting outreach workshops around local elementary/middle schools by May, to teach students about the wonders of space and space technologies as part of ***Mission: Reconnect 2020***. Students are invited to contribute small payloads for the capsule or

to create inspiring art murals to be printed on the capsule hulls and photographed against the curvature of the Earth at the highest point in flight. Details in next sections.

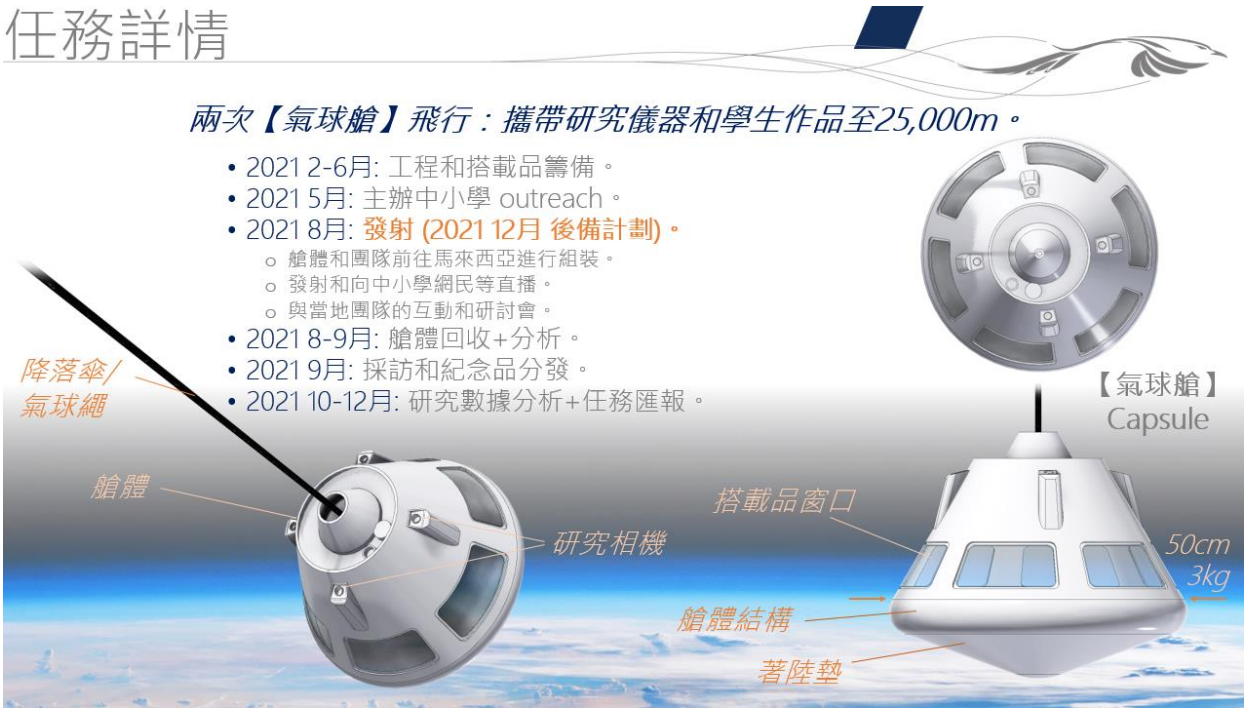

Fig. 3. Preliminary rendering of the mission's HAB capsule and approximate timeline.

## Invitation to Contribute Payloads

We envision the following potential format for outreach collaboration between NYCU and Keelung City's schools:

1. Early May: An info session will be scheduled in conjunction with Keelung City Government Education Department, inviting interested teachers from local high schools to attend. The info session will cover the inspiration for ***Mission: Reconnect 2020*** and details on how to participate.

2. End of May: We invite student teams to express their creativity and develop either scientific or artistic payloads of the following tentative specifications for inclusion in our flight:

| | |
|---|---|
| Payload Type | Scientific or artistic |
| Mounting | May be mounted inside (protected) or outside (space-like) the capsule |
| Mass | <100g |
| Size | <9x9x3 $cm^3$ |
| G-Load Robustness | Withstand 3G |
| Temperature | Withstand -60$^oC$ (outside) or -20$^oC$ (inside) |
| Pressure | Withstand vacuum |
| Electrical Supply | Possible. Please contact to arrange with our team. |
| Biological Payload | Need special review. |

Details of payload design and preparation will be taught to students and school teachers by our team. Depending on the number of interested schools, our team may travel in person to conduct a half-day lesson with student group, or elect to interact with multiple groups through virtual meeting. We hope such undertakings can complement part of your schools' scientific curriculum, and help bolster the schools' "space credential."

3. June-July: Our team with check on student progress frequently to make sure development of payload is on schedule.

4. July: Depending on the number of participating teams, we may elect to fly all student payloads, or down-select via a competition. Our capsule can tentatively accommodate three teams due to mass limitations.

5. Late-July: Team's final payloads will be mailed to NYCU and integrated by the capsule. The completed capsule will then be shipped for Malaysia for flight. Students may be invited to witness the integration process and ground tests.

6. August Launch day: We will arrange livestream of the mission from the ground (and perhaps from the capsule itself) to immerse students in the excitement of this near-space flight. Livestream may start at dawn with balloon preparation, and last through the flight and then capsule recovery phase. Upon recovery, all payloads will undergo "safing" (i.e. powered-down, preserved, data downloaded etc.) for return to participants.

7. September: Upon return from mission, payloads will be returned to the student teams for debrief. We will then conduct an overall mission debriefing to conclude this exciting journey.

## Project Costing

***Mission: Reconnect 2020***'s capsules and flights are presently fully funded via third parties through NYCU. Any additional funding from Keelung government is not critical *but highly appreciated*. However, the following small costs will require support from Keelung City Government Education Department and/or the participating schools should they arise:

- Cost of travel by our team between NYCU and Keelung if frequently required.
- Cost of travel by Keelung students to NYCU (to witness payload integration etc.).
- Cost of packaging/mailing student payloads to NYCU.
- Cost of student payloads.
- Etc.

## Mission Team and Qualifications

The mission team personnel and key qualifications are summarized in Fig. 4. This team involves USM's Dr. Norilmi, whose lab has had routine successful HAB flights in recent years, and who is a well-known figure among the Southeast Asia's space community. The team also involves Prof. Lua Kim-Boon's Aero-Tech Lab, which has cultivated numerous winning student competition teams for NCTU. Finally, the project is also led by Prof. Tan Zu Puayen's via ASARe Lab. Prior to joining NCTU, Prof. Tan was the founder of Boleh Rockets which launched Malaysia's largest rocket, and a technical consultant for Singapore's Equatorial Space Systems company which recently launched ASEAN's first privately-developed hybrid propulsion rocket from Malaysia.

This team has the full capacity to achieve mission success for ***Mission: Reconnect 2020***.


Fig. 4. Mission lead.

## Current Progress

Progress and latest details of ***Mission: Reconnect 2020*** can be followed at:

***https://www.asarenycu.com/zh-mission-reconnect-2020***