UNISEC-Global The 26th Virtual Meeting

October 8, 2022, 22:00-24:00
(Standard Japan time GMT +9)

The following report was prepared by UNISEC-Global Secretariat
October 8, 2022.
Japan

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1. Special Lecture on "Introduction of Mission Assurance Handbook for University-based Lean Satellite"

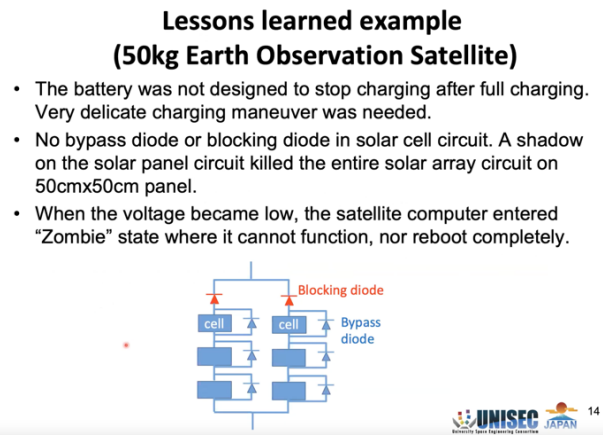
Mengu Cho, Kyushu Institute of Technology

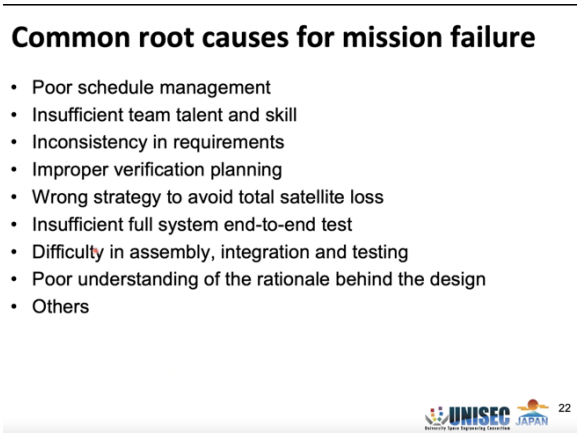
Prof. Mengu Cho received the B.S. and M.S. degrees from the University of Tokyo and the Ph.D. degree from Massachusetts Institute of Technology, in 1992. After working at Kobe University and International Space University, he joined Kyushu Institute of Technology (Kyutech) in 1996. Since 2004, he has been a worked as a full professor. Currently, he is the director of Laboratory of Lean Satellite Enterprises and In-Orbit Experiments. His research interests include spacecraft environmental interaction and satellite systems. Prof. Cho has supervised more than 11 university satellite projects, among which 9 projects, 16 satellites, are already launched. In 2019, he received the prestigious Frank J. Malina Astronautics Medal from International Astronautical Federation.

Pictured: Prof. Mengu Cho giving lecture on UNISEC-Japan's latest mission assurance handbook

Highlights:

- 2020 just start of the pandemic, everyone was grounded
- Remote presentations and survey to improve reliability of university satellites
- Analysis of success and failure, extraction of requirements for mission assurance
- 439 page report published through effort of UNISEC-Japan and JAXA
- 2021 the report was turned into a handbook
- "Mission Assurance Handbook for University-built Satellite" published in 2022
  Full Handbook:
  http://unisec.jp/ma/mission_assurance_handbook_en.pdf
- Lesson Learnt
  - Case of a 3U CubeSat, software development lagged behind hardware
  - Integration of satellite suppressed timeline
  - I2C issues created infinite loop of reset but recovered after 2 years
  - Not enough involvement and motivation of students
  - Complicated design for structure and poor management
  - Long term end-to-end test not done
- Case of 1U CubeSat, dead on arrival
  - Connected solar cells in the wrong manner (mistaking diode for electrode)
  - Delivery date fixed, deliver regardless of solution
- Case of 2U CubeSat, could not communicate from ground station
  - External supporters for communication support
  - Not enough experience with ground station and communication

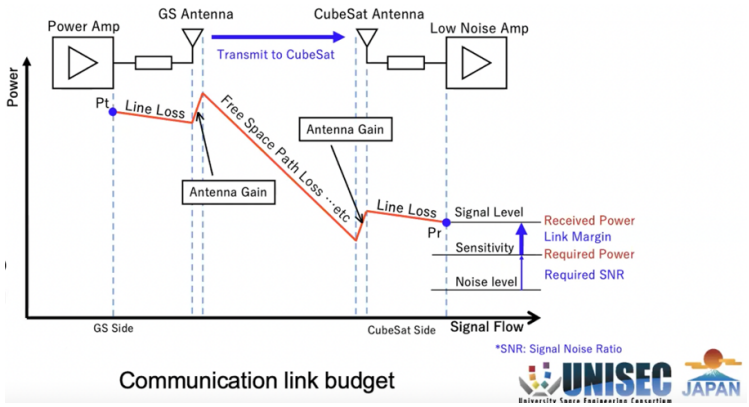




Pictured: Prof. Cho's explains what lessons could be learnt from previous satellite failures

- Case of 50kg Satellite, issue with power budget management
  - Electrical Power System (EPS): Reset because of higher power usage
  - Because of the reset, attitude pointing operation could not be done
  - No image downloaded
  - No "test-as-you-fly" done, no long duration tests done
  - Solar Panel: No bypass diode that destroyed all solar cell array in the circuit
  - Satellite in zombie state because no could it function or reboot completely
- Case of 7kg Satellite, over current protection (OCP) issue
  - First 3 weeks operation, no operation later due to Single Event Latchup (SEL)
  - OCP value without any clear logic
  - SEL testing not done on the ground, should have done missions earlier
- Case of Constellation of 5 x 1U CubeSat, communication issue (BIRDS-1)
  - UHF patch antenna, only weak CW
  - No system communication testing done because antenna came last minute
  - Lack of experience with communication
  - Strategy of making at least one satellite working
- Case of Constellation of 3 x 1U CubeSat, communication issue (BIRDS-2)
  - Uplink not successful because of the noise generated by EPS'
  - Overestimation of link budget by 10db because of reference antenna attenuator
  - Lack of knowledge how internal systems create noise, no proper link budget calc.
- Common problems: lack of experience, no end-to-end testing, wrong test strategy
- Mission assurance
  - Identify and eliminate/decrease design/operation issues for mission success
- Lean Satellite Concept (University satellites are lean)
  - Non-traditional, risk- taking method that decreases dev cost and time
  - Tolerates risk but still provides value to stakeholder by conducting missions
- Satellite Mission Assurance Handbook is
  - For university, startups, technical schools and anyone designing satellite
  - Organized in terms of project cycle, points so that it's easily implementable
  - Content is still relevant for non-Japanese organizations
  - Published and is online, available for free: http://unisec.jp/ma/mission_assurance_handbook_en.pdf
- Feedback from the community is very much encouraged
- Project Management
  - Not all the work can be done by the team, in such outsourcing is important
  - However, design requirement has to come from the team
  - The team needs someone who is familiar with satellite development cycle
  - Principal Investigator has to open channel for external support for team
  - Non-compliance to safety requirements by launcher can delay projects
  - Always design with safety review in mind, listing out early as possible helps
  - Lean Philosophy in Project Management
    - Important to do both value and non-value adding activity
    - Important to reduce waste (time, material, time looking for material)

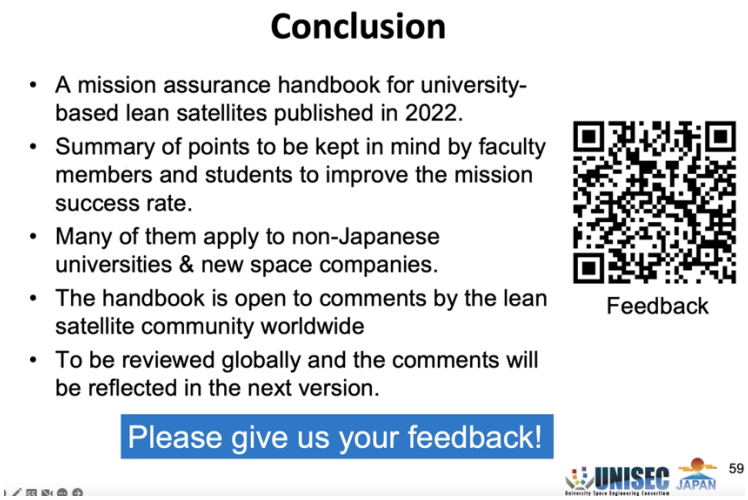
- Mission Definition Phase
    - Knowing team's limits in budget and capability is crucial
    - Professor or Supervisor might not know everything
    - Red flags when mature missions are going to be conducted in first satellite
- Conceptual Design Phase
    - Success criteria is important, make it as quantitative as possible
    - When design changes, keeping an eye on minimum mission success is key
    - Is the stakeholder happy with minimum success? Design to at least achieve that
    - Consistency between requirement and design, external opinion is important for cross checking
    - Do not use any design that cannot be verified, make a doable verification plan
- Detailed Design Phase
    - When buying from vendors, price and performance is not the key factor
    - Important is delivery time and compatibility + post-sales support
    - Minimize changes to BUS design as you launch more satellites to min. time/cost
    - Share design with vendor so that vendor can sustainably supply components
    - Find points of failure and mitigate the risk, Fault Tree Analysis (FTA) is helpful
    - External review can be helpful to check design and verification of systems
    - Use extremely reliable components make basic systems are working
    - Example: "God PIC" called PIC16F877
    - Confirm that battery can be recharged when it is completely discharged
    - Confirm satellite can recover after reset
    - Confirm that power budget such that satellite can work even in 50-60% capacity
    - When discussing design changes, always select the minimum risk case
    - Satellite should be in such a way that it is easy operate (simple commands)
    - Keep important housekeeping data/parameters before power reset of satellite
    - Ground Station (GS) testing done before and if possible, automatic operation
    - Reduce workmanship error by reducing harness and fasteners
    - Create external ports to access internal components, mating/un mating connectors many times might create problems in connection
    - Prepare jigs for storage of satellites, be extremely careful while handling satellite
- Production Stage
    - Relying on students for manufacturing workmanship is risky
    - Purpose is to teach systems engineering and project management
    - Safety requirement compliance is critical, complete all documents/process
    - Communication between launcher (safety reviewers) and integration team



Pictured: Proper link budget calculation and verification is crucial for mission success

- Testing Phase
    - Link margin and budget should be calculated and tested before FM
    - End to End testing is critical, command sent from GS and download data
    - Make very simple, basic end to end and then make it more complicated
    - Start functional test as soon as EM/FM components are delivered and integrated
    - Do not do environment testing (TVT, Vibration) without solving all issues
    - This way, if problem occurs, one can be sure that it is due to environment
    - End to End through satellite operation rehearsal allows to find bugs and fix them
    - Link budget calculation confirmation through Long Range Testing

    - If Dead-on-Arrival (DOA), most likely power failure
    - Fit check through official POD borrowed from launcher
    - For thermal vacuum testing, use worst case beta angles (use real flight data)
    - Better than thermal analysis
    - Confirm if the test equipment is calibrated or used properly
    - When testing, record as it is, document problems and solve. Be critical of results
- Operation Phase
    - For Ground Station, the antenna and radio connection should be as short
    - Should have easy access to antenna, and control room should be accessible 24/7
    - Periodic maintenance, pointing calibration (do not use compass to find north)
    - Receive frequency license as soon as possible
    - Do the main mission first, many satellites fail in first week or two
    - When failures do occur, the senior figures should motivate team, find issues
    - If issue, find information flow, conduct FTA (Fault Tree Analysis)
    - Eliminate method where each block in the system is tested, checked
    - If OK the block is removed until the issue system/software is found
- After Operation Phase
    - Documentation, sharing lesson learnt and know how
- Sustainability of university-built satellites
    - Difficult to write peer-reviewed academic papers from satellite projects
    - Responsibility of senior professors to help academic career of junior researchers
    - Build and strengthen university base and support university management
    - Project involves one professor to a program which involves multiple professors
    - For funding, there is no miracle. Effort is needed individually/collectively
- The handbook is open to comments by lean satellite community worldwide
- Global review and feedback will be reflected in the next version



Pictured: Proper link budget calculation and verification is crucial for mission success

2. Question and Answer Session

Morokot (AUPP): *I have a question regarding OCP. How do we test and confirm OCP? In other words, how to create latch-up conditions during the system test on ground?*

Mengu Cho: *Yes, it is a very important question. In our project, we do radiation test. Not in Kyutech but in Kyoto. We take the entire board and the MCU is irradiated by radiation and later latch happens. That is one thing. You may say we do not have a radiation facility; expose the plastic package of your processor you want to test to strobe light you use in camera very intensely. Sometimes it can cause latch up. That is what we found. Then you don't need any radiation. The photoelectrons in the circuit, too much of them cause latch up. So please try. It is better to test entire board.*

Yasir Abbas: *For expensive (i.e., 50kg satellites) can insurance cover design and human faults?*

Mengu Cho: *Yes, I recently talked to a person working in space insurance. Slowly, those new space companies, started to buy insurance. Not just launch but in orbit failure. For that, they need to disclose all the designs but yes, it is slowly starting. Not for university.*

Senior: *Can you explain why saving one CubeSat could have been a better strategy than saving all CubeSats?*

Mengu Cho: *Because if we save, at least one we can do the mission. We can communicate with the satellite, operate and get many things. If we lose all the five, we cannot get data. Because all the satellites are identical, we can still do the mission. Although the amount of data is as much as we have five satellites but still we can do something meaningful. That's why.*

Rafiki Yves: *Is there any problem to add at the end of the book an annex of recommended vendors based on the lessons you learned?*

Mengu Cho: *That needs to be discussed inside UNISEC. Probably very difficult. Cannot endorse any vendors. I can recommend secretly but not officially.*

Yasir Abbas: *Usually academic projects are not well documented. Do you think it is better to invest more time and efforts to document university projects properly?*

Mengu Cho: *I have a question Yasir, do you like writing document.*

Yasir Abbas: *No*

Mengu Cho: *A lot of students here today, any students like to write documents? If you like OK. Usually, it is very rare to find student who likes to write document. So even if assign somebody, usually it does not work. One way is to link student's task to student's undergraduate or master's thesis. Then students have to write all in depth what he/she has done. That is one way. It does not cover entire project but yes. Besides, professors and academic staffs, they have to write document. They don't write but they have to write. They are usually much better writers than students. So, they can write the document. I almost gave up making students write documents. However, just keep minimum and important things, necessary ones. For the know-how transfer, we use to get the experience of student, staff and over-arching generation of student so that they can assist each other. That's the strategy I am taking. I don't think it is the best way but that is one way. Yes.*

Yasir Abbas: *Of course, students don't want to document but this will significantly help, in terms of project management of the program or the project, can prepare forms or way of easy-ing that documentation. So, students have to fill that form. This could be a way to ease the documentation and help the project to achieve success.*

Mengu Cho: *We must have that system or I should have very charming skills to persuade students to work on documentation.*

Jyh-Ching Juang (Taiwan): *If a proto flight model (PFM) is adopted, which mission assurance guidelines should be adopted?*

Mengu Cho: *I think many of them applies. Some of this one does not apply. Assuming that going through EM and FM, many things apply. For first satellite project, the team won't apply proto-flight approach. For experienced team, this approach may work. Still for testing it applies and for mission definition/conceptional design phases*

also applies. How to see the mission feasibilities, whether those missions is approved by satellite bus or not. Still applies.

Fahd Moumni: *What can be done by a principal investigator to motivate the students?*

Mengu Cho: *We have to make the students think that is their satellite. I am not sure whether if I am successful in that one.*
Fahd Moumni: *Sensei, I think you were able to. In BIRDS-5, that's exactly what we felt like. Maybe it was more naturally, but it was true.*

Mengu Cho: *Sense of ownership, right?*

Fahd Moumni: *Yes*

[Unknown]: *My question was how do you ensure that one specific CubeSat out of five would succeed. Do you accomplish that by providing more resources to one CubeSat or do you prioritize just one out of the five CubeSats that you are developing? What's the approach?*

Mengu Cho: *Still, we make an identical design but still workmanship different, some random variations among them. Some may work, some not work. By simply having more numbers, we improve the success rate. We try to make the same procedures but some may fail, some may survive. But simply avoid risk, if there's very new technology. Such as using completely new radio. And I think it's kind of risky, that radio may not work. And if that does not work, all the satellite fails. Yes, Yasir is correct, applying less risky designs. So we can improve the chance of success.*

Alim Rustem Aslan: *I have a question, you have accomplished many CubeSat projects, what was the minimum budget required to complete the project?*

Mengu Cho: *Many people ask me how much it would cost. For first satellite project, around $200,000 including building infrastructure like ground station. Of course, testing will be outsourced. For the later satellite projects, as we continue more cost will go down. If we build many things in-house, design many things in-house, the outsourcing cost will go down. And if we design many things in-house and outsource PCB making and those things. Right now, the cost is about, one satellite $40,000 or something.*

Alim Rustem Aslan: *For 1U?*

Mengu Cho: *Yes, we are trying to make it much cheaper. Less than $30,000.*

Alim Rustem Aslan: *Only equipment cost?*

Mengu Cho: *Yes, only hardware.*

Alim Rustem Aslan: *Just hardware, no Engineering, of course, launch is not included.*

Mengu Cho: *If you include launch, $100,000. If you use J-Cube, you can launch in $30,000. So total about $60,000.*
Alim Rustem Aslan: *There is another issue, if you are in a space fairing country, development is much cheaper. If you do it in non-space fairing country, your $40,000 will may be go to $400,000.*

Mengu Cho: *It's a really a matter of procurement, yes. How to procure those components. We need to find a way, how to design the satellite, the parts, the components in those company.*

Alim Rustem Aslan: *When you say $40,000, you are considering a simple mission. If you go for a S-band, X-band, the ground station they get very expensive.*

Mengu Cho: *Yes, sure. Of course.*

Alim Rustem Aslan: *What is your suggestion for university missions? Regarding the complexity.*

Mengu Cho: *For the university satellite, if it's educational and technology demonstration, many cases can be done just using amateur. For some case, yes, they need attitude control. In such case, the professor needs to get proper funding.*

Alim Rustem Aslan: *Since simple electronics or ground electronics are getting better and better, it seems some Arduino or STM based, ready-cheap camera, I think maybe can be tested in space. What do you think?*

Mengu Cho: *Yes, there are many flight-heritage of Raspberry Pi and things yes. And yes, it is getting cheaper.*

Alim Rustem Aslan: *In one of the last missions, we used a Raspberry Pi camera and now it's working. It is taking photo, no problem.*

Mengu Cho: *I think the key component that makes price high is radio. Radio because we need special know-how of microwave and digital circuit yes. And solar cells, and solar cell glue. Those three are most expensive in keeping the price high. If you have a new way to solve those issues, the price of simple 1U CubeSat will go down drastically.*

Mohamed Yahia: *Can we extend the standards to cover more areas about CubeSat developments?*

Mengu Cho: *Yes, I welcome suggestion. Please write email. I don't think I covered entire report.*

Hoda Awny: *Can Emerging Space programs follow the same philosophy?*

Mengu Cho: *Yes, I think so. Definitely. The lean philosophy is going after low cost and fast delivery. Minimize the waste. In emerging countries, they have to do it lean anyway. Because the humans are limited, talents are limited, the money is limited, time I don't know. So, they have to do it lean anyway. So, it's really applicable to the emerging country.*

Samuel Ndayizeye: *Thank you for the great presentation and sharing of all the questions. I have one question for emerging space programs as well. You have been to different projects and some of them successfully and good things happened. My question is, what is the biggest challenge among all the space projects that you have done. How did you approach is so that, these space fairing countries face similar challenges go forward in similar way?*

Mengu Cho: *To me working with emerging countries, the challenge is that I think the challenge is having good relation with the stakeholders. So, we have to communicate with them very well so because it is not one shot. To be sustainable, we accept students, we train them, so that they can have a future. They have to have a future in their country. Also, the funding issues. We must have a contract with stakeholders and contract is very complicated especially with those countries. And every country has different rules. So, every time, it is a challenge. I think we can manage. Mostly having good relation and also continuous relationship, it becomes issue of sustainability. Launching first satellite is not the end. After launch first satellite, based on lessons, they have to build second satellite. They have to make their own mission policies to make satellite by themselves. So, sustainability.*

Mohamed Yahia: *How to go out from the current crises? Pandemic, low electronics available, ...low funding*

Mengu Cho: *Pandemic was very tough. But we learned and learned to work remotely but for satellite building we had to come together. BIRDS-5 was built entirely in pandemic time. But we could manage. Many people survived pandemic time. Low electronics available, yes, it is really a headache. Somehow, we are surviving. I hope the situation gets better. Low funding? I don't know. Like I said before, the money does not come from heaven.*

3. Announcement and Acknowledgement

Rei Kawashima, UNISEC-Global

- **New Point of Contact (POC), Netherlands**
  - Mehmet Sevket Uludag, Delft University of Technology

- **11th Nano-satellite Symposium**
  - Presentation: October 17, 18, 19 (morning)
  - Pre-MIC 8 workshop during the event
  - Official website: http://nanosat11th.itu.edu.tr/index.php

- **Pre-MIC 8**
  - Presentation at workshop (not contest), October 19, 2022 in Istanbul
  - Official website: http://spacemic.net/

- **8th UNISEC-Global Meeting**
  - UNIGLO opening: October 19, 2022 in Istanbul
  - Local chapter presentation and breakout session: October 20, 2022
  - Local chapter empowerment workshop: October 21, 2022
  - Official website: http://www.unisec-global.org/meeting8.html

- **27th Virtual UNISEC-Global Meeting**
  - November 19, 2022 22:00-00:00 JST time (every third Saturday of every month)
  - Theme: "Space Education, Transfer of Technology, and Capacity Building in Developing Countries"
  - Moderator: Prof. Mohamed Khalil
  - Confirmed Spealer" Prof. Sherif, Prof. Argoun, Prof Zahran
  - Hosted by **UNISEC-Egypt**
  - Seeking host for Dec 17, 2022
- Details of **J-CUBE** opportunity
  - Special (discounted) launch opportunities (1U-3U) [Almost 1/3rd price]]
  - Collaboration with UNISEC-Japan's university, application deadline: **Dec 28, 2022**
  - Website: http://unisec.jp/serviceen/j-cube

- Details of **39th International Symposium on Remote Sensing of Environment**
  - Turkey: April 24-28, 2023
  - Oct 14, 2022 Extended Abstract Submission
  - Nov 18, 2022 Abstract Acceptance Notification
  - Dec 02, 2022 Deadline for Early Bird Registration (March 01, 2023 Camera Ready)
  - https://isprs.org/documents/orangebook/app5.aspx
    https://isrse39.com

- Details of **Pre-8th Mission Idea Contest (PreMIC8)**
  - MIC in 2023. In 2022, hosting regional competition is encouraged
  - Pre-MIC8 workshop will be held in Istanbul (or virtually) in October 2022

- Mission carried by multiple satellites made of 6U CubeSat or smaller
- No restriction on the number of satellites as long as there is logic to support that
- Constellation with no inter-satellite link missions and formation missions with inter-satellite link both are encouraged

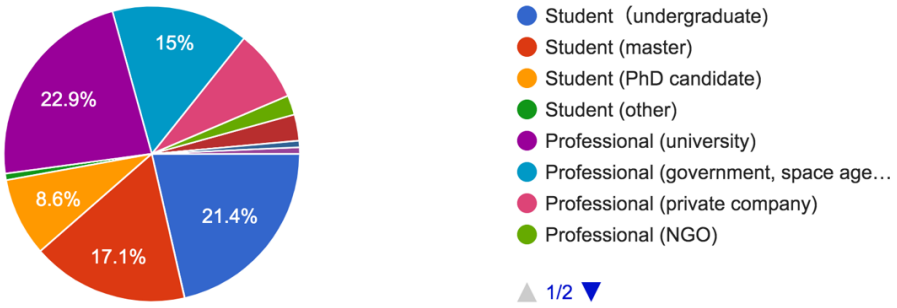
4. Participant Statistics

140 registered participants from **39** countries and regions for the 26th Virtual UNISEC-Global Meeting.

Country/Region	Number of registrations	Country/Region	Number of registrations
Argentina	1	Myanmar	1
Australia	2	Nepal	1
Bangladesh	5	New Zealand	1
Bulgaria	2	Nigeria	1
Cambodia	2	Pakistan	2
China	1	Paraguay	1
Colombia	1	Perú	1
Egypt	7	Philippines	23
El Salvador	1	Romania	1
Germany	1	Rwanda	1
Ghana	1	Taiwan	1
Guatemala	1	Thai	1
India	8	Tunisia	3
Indonesia	2	Turkey	8
Italy	1	United Arab Emirates	2
Japan	41	United Kingdom	2
Kazakhstan	4	United States	2
Kenya	2	Vietnam	1
Malaysia	1	Zimbabwe	1
México	2		

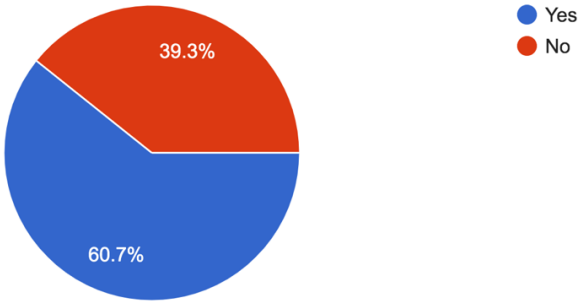
Student or professional?

140 responses



Have you participated in the UNISEC-Global Meeting previously?

140 responses



Thank you