Agenda

Overview of UPDWG and TechNet-21

Introduction to drones in Immunization Supply Chains (iSCs)

UNICEF case study - Vanuatu

VillageReach case study - DRC

Operationalization considerations & resources

Panel discussion
Overview of UPDWG and TechNet-21

Olivier Defawe - Coordinator, UPDWG
Alex Pascutto - Coordinator, TechNet-21
Unmanned Aerial Vehicles (UAV) for Payload Delivery Working Group (UPDWG)

UPDWG is a global community of stakeholders interested in the development, advancement and application of UAVs (or drones) for use in health systems.

Development of a shared evidence base

Hosts quarterly webinars

Produces monthly newsletters

Promotes partner coordination

Find out more and join us at UPDWG.org!
- A global network of immunization professionals committed to strengthening immunization services

- Established in 1989, managed by WHO & UNICEF

- Focus on cold chain equipment, immunization supply chain and logistics, and immunization service delivery and programme management

- TechNet Conference (2020)

Join us: www.technet-21.org
Introduction to drones in immunization supply chains

Olivier Defawe – Coordinator, UPDWG
Immunization delivery remains a challenge in many countries

Supply chain challenges are even more pronounced at the last mile – or the most geographically inaccessible areas
Drones may help reach these populations
Drones are where trucks were 70+ years ago

<table>
<thead>
<tr>
<th>Sub-System Elements</th>
<th>1940s</th>
<th>Now</th>
<th>Now</th>
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</thead>
<tbody>
<tr>
<td>Ground &amp; Manned Air Transport</td>
<td>⬗</td>
<td>⬗</td>
<td>✅</td>
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<tr>
<td>UAS</td>
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<tr>
<td>Technology Reliability</td>
<td>⬗</td>
<td>✅</td>
<td>⬗</td>
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<tr>
<td>Operation &amp; infrastructure</td>
<td>🌤</td>
<td>✅</td>
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<tr>
<td>Logistics cost</td>
<td>⬗</td>
<td>✅</td>
<td>⬗</td>
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<tr>
<td>Human resource for operation</td>
<td>🌤</td>
<td>✅</td>
<td>🌤</td>
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<tr>
<td>Solution integration</td>
<td>⬗</td>
<td>✅</td>
<td>⬗</td>
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<tr>
<td>Business model</td>
<td>⬗</td>
<td>✅</td>
<td>⬗</td>
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<tr>
<td>Safety regulation</td>
<td>⬗</td>
<td>✅</td>
<td>🌤</td>
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<tr>
<td>Cargo safety regulation</td>
<td>⬗</td>
<td>✅</td>
<td>🌤</td>
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<tr>
<td>Public acceptance</td>
<td>⬗</td>
<td>✅</td>
<td>🌤</td>
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<td>Impact research</td>
<td>⬗</td>
<td>✅</td>
<td>⬗</td>
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Go: ✅, No Go: ⬗, In progress: 🌤
Value add of drones in supply chains

Drones have the potential to have a high impact on particular supply chain challenges, when used as a complementary transportation method in existing immunization supply chains.

Supply Chain Design
- Optimize last mile deliveries
- Reduce transport time
- Integration with other commodities
- Reverse logistics from remote facilities
- Potential to increase cost efficiency

Utilization
- Increased demand for communities with infrequent supplies
- Bring products closer to health facilities
- Potential for faster disease diagnosis and faster treatment

Health Worker Efficiency
- Decrease time spent on logistics and away from health post
- Potential means of communication for remote facilities
- Improve time from delivery to reporting
- Optimizing stock kept at the last mile

Distribution & Replenishments
- Quickly replenishing hard to reach areas, missed populations or campaigns
- Ad-hoc deliveries during emergencies
- Potential to decrease temp. excursion
Despite the potential value, drones have had a slow uptake in the health delivery market.

**Global Drone Use in Immunization Supply Chains**

**Phase 1:**
Advocacy & testing

**Phase 2:**
Ongoing use & validation

**Phase 3:**
Expanding impact

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**DRC 2019** (DRC MoH, VillageReach, Swoop Aero)

**Vanuatu 2018** (Vanuatu MoH, UNICEF, Swoop Aero, Wingcopter)

**Vanuatu 2019** (Vanuatu MoH, UNICEF, Swoop Aero, Wingcopter)

**Ghana 2019** (Ghana MoH, Zipline)

**Rwanda 2016** (Rwanda MoH, Zipline)
Vanuatu: Vaccine Delivery by Drone
UNICEF Drones Program
UAV for Payload Delivery Working Group
190 COUNTRIES AND TERRITORIES

70 YEAR OLD ORGANISATION

INVOLVED IN +300 EMERGENCIES EVERY YEAR

LARGEST BUYER OF VACCINES FOR CHILDREN IN THE WORLD

47 MILLION CHILDREN REACHED WITH EDUCATIONAL SUPPLIES

6 BILLION DOLLARS OPERATION (90% DIRECTLY TO PROGRAMS)
Reach the most vulnerable

1bn people live 2km or more from an accessible road

50% of the world’s children rely on vaccines from UNICEF

20m children do not receive vaccines because they live in remote areas
Vanuatu

Population > **270,000** (2016)

Archipelago > **80 small islands** of volcanic origin.

Runs **1,600 km** north to south

**65 islands** are inhabited

Only **20** have airfields or roads

Many islands are **only accessible by boat**, the road network is incomplete or inexistent.
Challenges to service delivery

Limited infrastructure, expensive and minimal transport options:

- Air transport fleet antiquated, few suitable airfields.
- Limited road networks and in variable state of repair
- Access to fuel is problematic
- Islands reliant on unkept walking tracks
- Movement of supplies and passengers by sea, but lack of commercial shipping fleet makes scheduled sea transport to many islands very expensive
~ 20% of Vanuatu’s children miss out life-saving vaccines

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Schedule</th>
<th>Multiple Indicator Cluster Survey vaccine coverage**</th>
<th>Demographic and Health Survey vaccine coverage§</th>
<th>Vanuatu Vaccination Coverage Survey 2016: % coverage 12–23mo* at time of survey (95%CI)^ by card or recall*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-tuberculosis vaccine (bacille Calmette-Guérin)</td>
<td>Birth</td>
<td>80.6%</td>
<td>72.9%</td>
<td>94.6% (92.5–96.8%)</td>
</tr>
<tr>
<td>Diphtheria, pertussis and tetanus; Hemophilus influenzae type b; hepatitis B (first dose pentavalent)</td>
<td>6 weeks</td>
<td>78.5%</td>
<td>76.2%</td>
<td>94.0% (91.6–96.4%)</td>
</tr>
<tr>
<td>Diphtheria, pertussis and tetanus; Hemophilus influenzae type b; hepatitis B (third dose pentavalent)</td>
<td>14 weeks</td>
<td>63.4%</td>
<td>55.1%</td>
<td>81.1% (77.5–84.7%)</td>
</tr>
<tr>
<td>Three doses of oral poliomyelitis vaccine</td>
<td>14 weeks</td>
<td>61.1%</td>
<td>52.0%</td>
<td>81.3% (77.7–84.9%)</td>
</tr>
<tr>
<td>First dose of measles-containing vaccine</td>
<td>12 months</td>
<td>52.5%</td>
<td>52.6%</td>
<td>84.0% (79.9–88.0%)</td>
</tr>
</tbody>
</table>
• Provided at hospitals, health centers, and health dispensaries through **fixed** and **outreach** sessions.

• Fixed clinic sessions target **mothers who travel to health facilities** and occur weekly (141 facilities).

• Outreach sessions are **provided at aid posts** (the most decentralized facility) in remote communities by **health workers who travel from cold chain-capable health facilities**.
# Target population for immunization program (2018)

<table>
<thead>
<tr>
<th>Province</th>
<th>Target population children under 1 year in 2018</th>
<th>Number of health centers</th>
<th>Number of dispensaries</th>
<th>Average target population per health facilities*</th>
<th>Annual budget for outreach ($USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tafea</td>
<td>1,380</td>
<td>4</td>
<td>13</td>
<td>81</td>
<td>$19,555</td>
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<tr>
<td>Malampa</td>
<td>1,093</td>
<td>9</td>
<td>19</td>
<td>39</td>
<td>$24,935</td>
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<tr>
<td>Penama</td>
<td>1,217</td>
<td>6</td>
<td>23</td>
<td>42</td>
<td>$35,373</td>
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<tr>
<td>Shefa</td>
<td>2,945</td>
<td>6</td>
<td>13</td>
<td>155</td>
<td>$22,044</td>
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<tr>
<td>Torba</td>
<td>378</td>
<td>3</td>
<td>5</td>
<td>47</td>
<td>$15,083</td>
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<tr>
<td>Sanma</td>
<td>1,985</td>
<td>8</td>
<td>18</td>
<td>76</td>
<td>$50,544</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>8,998</strong></td>
<td><strong>36</strong></td>
<td><strong>91</strong></td>
<td><strong>71</strong></td>
<td><strong>$167,534</strong></td>
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<tr>
<td>Urban</td>
<td>3,152 (35%)</td>
<td>3</td>
<td>2</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>5,846 (65%)</td>
<td>33</td>
<td>89</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>
Immunization supply chain (iSC) in Vanuatu

- **“Pull” arrangement**
- **3 levels:** national, provincial and service delivery.
- **National Vaccine Store:** Receives vaccines from UNICEF, 12 months stock / 3 months safety
- **Provincial:** 3 months stock / 1 month safety
- **Health centers:** 1 month stock / 2 weeks safety
**Operation costs to reach every child < 1yo (2018)**

**USD$20 per child** is the average operational cost to reach all children in Vanuatu.

More than 90% is for transportation:

- 72% transport
- 20% DSA for nurses
Rationale to use UAS in the iSC

- **Reduction in medical supply costs**: Fewer losses, expiry of medicines and/or overall stock efficient management;

- Use of drones for **flexible delivery / redistribution**;

- **Reduction in cold chain equipment costs** as a reduced need for decentralized refrigeration;

- More **productive use of time for health workers** (who would still need to travel to aid posts to administer vaccines but without the responsibility of transporting them from health centers);

- Transport of other **life-saving medical supplies**.
Objectives

Test UAS as a new mode of transportation for the Expanded Programme on Immunization (EPI) as a last-mile delivery resource:

- Is it **technically feasible** to integrate drones into the existing health supply chain?
- Is the technology **accepted by local communities**?
- Viability of facilitating and administering **safe drone-based services** within Vanuatu’s national airspace
Vaccine Delivery Trials (VDT)

- Ministry of Health and Ministry of Infrastructure and Public Utilities (under which CAAV is administered)

- Endorsed on June 1st, 2017 by Cabinet, which requested UNICEF to support.


- Designed in 3 phases:
  - **Phase 1**: Self-funded (2017), open and scored challenge (2018-19)
  - **Phase 2 (2019)**: Open and public procurement process for 3 tenders to commercially deliver vaccines over 9 weeks to communities in the islands of Pentecost, Epi, Erromango, and the islands in Shepherd.
  - **Phase 3 (TBD)**: Integration of UAS to health supply chain at national level.
Community engagement

- > 110 different cultures and languages.

- Communities, schools and health facilities under the proposed flight paths were visited by staff from MoH, CAAV and UNICEF (early 2017).

- Teams engaged with nurses responsible for maternal and child health and EPI, as well as teachers and school children.

- Discussions were held with community leaders: Chiefs, pastors, women, and youth leaders.

- Contractors worked closely with nurses to raise awareness & safety precautions.

- Nurses sensitized the community in the islands.
VDT: Phase 1 (V1.0, August 2017)

Phase 1
Self-funded challenge
(concept)

- 3 scored flights through waypoints defined by GPS & deliver a package with inactivated vaccines (80/100)
- Temp to be maintained 2-8° C
- Landing at delivery site not required
- Equipment specs, delivery systems, and vaccine carriers were open to participants choice
**Phase 1**
Dec 2018 – Jan 2019

**Score:** 80 / 100 to pass to Phase 2

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**Swoop Aero**
3 Dec – 14 Dec, 2018

**Score:** 93.42 / 100 – Passed

- Completed 1st day tasks satisfactorily
- On 2nd day, drone crashed into a hillside, between Mapua (W2) and Marow (W3).
- Mismatch between the elevations set for waypoints in the contract & the terrain model to program the mission
- Postponement of 1 week due to bad weather conditions
- Passed to P2: Only had minor issues flying through certain waypoints and with the accuracy of the delivery.

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**Wingcopter**
16 Jan, 2019

**Score:** 87.5 / 100 – Passed

- Had to await the arrival of operation-sized LiPo batteries and was also constrained by lack of relay antennas for BVLOS operations
- Postponement of Phase 1 until mid-January 2019
- Passed to P2: MoH established 2 conditions, improve their vaccine carrier to maintain the temp of vaccines & demonstrate to CAAV that their drones can fly safely BVLOS & BRLOS with relay antennas installed.

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**May 2018:** Tender period

**Oct 2018:** Vanuatu government signed contracts with 2 companies, requiring them to pass Phase 1 to qualify for P2

**Coordination:** MoH, CAAV, Ministries of Foreign Affairs, Immigration and Customs to facilitate visas and importation

**Location:** Efate Island (near Port Vila), airstrip in Takara (out of the controlled traffic region boundary & accurate representation of islands)
### VDT: Phase 2 Prep

**Phase 2: 9-week delivery of vaccines**

- Deliver the **monthly demand** of vaccines and medical supplies from distribution centers to dispensaries, aid posts, mobile teams *(one-way)*.

- Design and implement **Logistics Operating Procedures** (LOPs).

- **Coordinate with MoH**, and health workers on the field to implement their LOPs.

- **Coordinate with CAAV** to safely accommodate BVLOS flights and obtain approvals.

- Keep their **UAS fleet always operational** (backup unit capable of long range and BVLOS), no justification for not complying with the delivery schedule.

- **Train health workers** who will receive the cargo at drop points, and address operational and safety standards (especially if the UAS has to land).

- Prepare and check equipment to **maintain temp between 2 and 8 Celsius**.

- Deliver vaccines and medical supplies according to their LOP and schedule.
- **UAS landed at delivery site** and nurses were trained to retrieve the payload.

- Satellite communication link.

- Landing UAS allowed for increased opportunities for community engagement, redistribution, and **two-way deliveries**.

- Scheduled deliveries + on-demand deliveries (nurses send SMS to DC asking for vaccines and received them in 20-30 min).

- Random school visits and order exact number and type of vaccines needed.
Wingcopter, Phase 2

- UAS didn’t land and delivered payload through a winch mechanism hovering at 10.5 m above the delivery site (measured with LiDAR)

- Radio mesh network (needed to install relay antennas in mobile telecom towers) + Satellite comm link.

- Not landing UAS allowed to rapidly (and safely) expand the number of delivery sites (training to nurses was less intensive).

- Scheduled & on-demand service delivery, only one-way deliveries.
Delivery of other commodities

Buy-in of the technology from the community, an example is the demand for the delivery of other commodities:

**One way:**
- Envelopes, paperwork, syringes.
- Other medical supplies: phenobarbital (medication for epilepsy), oxytocin (post-delivery bleeding).

**Two-way:**
- Re-distribution of antibiotics, oxytocin, malaria tabs and strips, creams, a doppler, iron supplements, dental supplies, payments and payslips for nurses.
- Between dispensaries and from dispensaries to distribution centers.
Results

Drones can safely deliver temperature-controlled medical supplies to last-mile communities (over 70km):

- Reduced an hours hike for a 25 min flight.
- > 150 BVLOS flights, ~ 6,000 km of mountainous terrain covered.
- +35 kg of high medical supplies to 33 different locations.
- All vaccines delivered within acceptable temperature limits.
- Increased engagement with EPI

Over 9-weeks: 1,066 women and children were immunized with vaccines delivered by drone

<table>
<thead>
<tr>
<th>Age</th>
<th>Pentecost</th>
<th>Erromango</th>
<th>Epi</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children under 1 year</td>
<td>467</td>
<td>26</td>
<td>93</td>
<td>586</td>
</tr>
<tr>
<td>Children 1–5 years</td>
<td>3</td>
<td>19</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>School children</td>
<td>256</td>
<td>0</td>
<td>112</td>
<td>368</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>73</td>
<td>0</td>
<td>17</td>
<td>90</td>
</tr>
</tbody>
</table>
Lessons (for Phase 3 and other implementations)

- **Landing system is preferable**: Addresses both supply streams (health workers are able to send a vaccine arrival report directly back with the drone after reviewing freeze-tags and vaccine vial monitors) and increases community interaction with the drone.

- **Upstream supply chain re-design**: Re-calculation of forecasts and distribution frequency to ensure maximum supply chain benefits in response to increased throughput.

- **Large number of flights is required to reach a competitive tipping point**:  
  1) Projects to be a minimum of 12-month operational trial period (through which reliability can be assessed, both cost utility and cost effectiveness can be fully examined);  
  2) An internal review of the entire health supply chain be undertaken against inclusion of drones-based logistics; and,  
  3) Drone services be widened beyond the health sector to optimize equipment usage

- **Achieve sustainability by building local capacity and skills**: Employ local staff for operation and maintenance of drones.
Empower young people with skills

To use drones sustainably at scale you need local capacity

- Prepare youth with an education in tech and business to get jobs as drone pilots and technicians, or launch their own venture

- Free education to 25 African students every 3 months for the next 2 years

- TOP Level 2 Remote Pilot + Skills to build and maintain UAVs + Data science

AFRICAN DRONE & DATA ACADEMY
Mалауи
Starting early 2020

UNICEFINNOVATION
@unicefinnovate
Thank You

Jaime Archundia (@JaimeArchM)
Global Lead – UAS
UNICEF Innovation
jarchundia@unicef.org

@unicefinnovate
NGCA (Next-Generation Supply Chains)

Started in Equateur Province as a partnership with the DRC Ministry of Health (National & Provincial) and VillageReach to improve the supply chain and product availability

Empowered human resources

Direct delivery of health products

Access and use of data

Equateur Province
Population 2.6 M
Area > 100,000 km²
Integrating drones into the NGCA Initiative

Multi-sectoral collaboration
between the DRC MoH, CAA, VillageReach, Gavi and Swoop Aero

Demonstrated two-way transport
of immunization and other medical commodities using drones

Built commitment for Phase 2 scale-up
among stakeholders from all levels
Journey to introduce drones
Phase 1 began with a multi-pronged approach:

- Governance
- Aviation & Health Regulations
- Technology
- Acceptability

Evidence Generation
Governance

- National Drones for Health Commission & Provincial Working Group formed
- Authorities involved in drone flights and activities
- Learning visits to other countries with UAV projects
- Go/No-Go decision framework developed for scale-up
- Country decision to expand intervention
Aviation & Health Regulations

- Civil Aviation approved drone partner
- Approvals for drone import and use
- Flight routes approved
- Direct coordination of flights by Civil Aviation & Air Traffic Control
- Emergency and communications protocols
- Standard procedures followed for resupply, transport and reporting via drone
Acceptability

- Pre and post-flight stakeholder perceptions study with MoH
  - Found low level of familiarity but high acceptability of the technology
- Multi-pronged community sensitization strategy and public communications campaign
- Babies publicly immunized with drone-delivered vaccines
- High-level and local ceremonies during drone flights
Technology

✓ Global request for proposals for drone partner selection
✓ Weeks of preparations and stakeholder coordination prior to flights
✓ Test flights conducted before official demonstration flights
✓ EPI and health center staff trained on drone operations
✓ Preliminary assessment of local capacity
Evidence Generation

✓ 50 flights traveling over 2000 km in the air, in 5 days
✓ 80 km round-trips, at 115 km/hr, reduced transport time from 3 hrs to ~ 20 min
✓ 25 kg of vaccines, syringes delivered for 5 rural health areas to immunize 470 children, plus medicines
✓ Cold chain maintained & reverse logistics demonstrated with lab samples, reports, letters, etc.
✓ No safety or product concerns, two drones flew at same time on opposite routes
✓ Quick adoption by local EPI and health staff
How do we get from introduction to integration?

**Phase 2:**
Routine use & validation
Planned for 2020

- **12 months of integrated deliveries to 25 remote areas in Equateur province**
  - Strengthen enabling environment and build local capacity
  - System (re)design
  - New flight approvals, import, evaluation strategy, sensitizations
  - Generate evidence on performance and costs
  - Develop business plan for scale up and sustainability

**Phase 3:**
Expanding impact
Planned for 2021 & beyond

- **Expansion beyond Equateur province**
  - Additional provinces, settings, health commodities, and use cases
  - Coalition of partners (public-private partnership)
  - Data on health and economic impact
## It takes a village... Acknowledgments and thanks

<table>
<thead>
<tr>
<th>DRC Ministry of Public Health</th>
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<tbody>
<tr>
<td>EPI at national and provincial level</td>
</tr>
<tr>
<td>Provincial Health Division Equateur</td>
</tr>
<tr>
<td>Community leaders</td>
</tr>
<tr>
<td>Gavi</td>
</tr>
</tbody>
</table>
Operational Considerations & Resources

Olivier Defawe – Coordinator, UPDWG
Operationalizing Considerations

Lessons learned across countries

- Multi-disciplinary stakeholders need customized messages and approaches
- In new settings, understand technology awareness gaps and perceptions
- Gov't leadership and ownership is critical
- Be prepared if things don't go as planned during flights
- Capitalize on reverse logistics and integration opportunities
Resources

Visit the UPDWG resource library for all of these resources and more
https://www.updwg.org/resource-library/

UAS considerations for Immunization Supply Chains – A System Design Approach – Gavi and the Interagency Supply Group (soon to be released)

UAS: Product Profiles and guidance - UNICEF

UAV Delivery Decision Tool – FHI360

What Should You Deliver by Autonomous Aerial Systems? Tool for Determining Cost Effective Use Cases for AAVs – InSupply & JSI

Interagency Supply Group UAS Coordinating Body website

Contact the UPDWG coordinators if you have additional questions or would like to be connected with UAV providers, donors, implementing partners, etc.

info@UPDWG.org
Panel Discussion

Jaime Archundia - UAS Global Lead
Ridwan Gustiana - Health Specialist, Immunization

Luciana Maxim - Sr. Manager, Research Evidence and Learning
Dieudonne Nsekela - Program Officer, New Technologies

Christian Vazquez - Civil Engineer, Transportation Engineering (formerly UNICEF Vanuatu)