DOOSAN

Power for Tomorrow

Doosan Mobility Innovation

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Chapter 1. Introduction to Doosan Mobility Innovation

Who is Doosan?

Global Enterprise

- ✓**38** Overseas Branches
- ✓**120** Overseas corporation
- ✓**1,700** Overseas Dealers

Sponsorship

Group Rev. **18.5** billion USD

| 38 overseas branches and 120 overseas corporation |

What does Doosan do?

		Doosan Corporation	Heavy Industries	Infracore	Bobcat	Others
Infra Structure Business	Energy	PA Fuel cell  FCP  Mobility Innovation 	Power Plant  Green Energy  			
	Machinery	Forklift 		Construction Equipment 	Compact Equipment 	Collaborative Robot 
	Component/ Material	Electro-Materials  Hydraulic Components 	Casting & Forging 	Engines 		Autonomous Logistics 
	Other Heavy Industries	Chemical Process Equipment 	Water Plant 			Engineering & Construction 
Customer & Service Business		Shopping mall 	Investment NEOPLUX INVESTMENT COMPANY		Golf Club 	Advertisement ORICOM IMC IDEA GROUP

Why did Doosan start fuel cell drone business?

Doosan is the Leader in the Global Fuel Cell Business.

50 Years PAFC Experience

30 Years PEMFC Experience

Miniaturized Fuel Cell Can be new power source For mobility industry

Doosan Mobility Innovation

Mobile PEMFC

How Doosan's assets support fuel cell drone business?

Proven fuel cell technology

PA Fuel Cell

PEM Fuel Cell

Experience in mass-production of industrial products

Compact Equipment

Construction/Industrial Equipment
(Excavator, Loader, Truck, Forklift)

Internal test bed or Captive markets

Power plant
(Coal, Nuclear, Solar, Wind)

Engineering & Construction

Investments in Innovation

Digital Transformation

Collaborative Robot

Doosan Mobility Innovation

Based on PAFC / PEMFC's Technology, Supply base, Production

Doosan Group's Stable funding but Independent Corporation for "Speed & Flexibility"

Test bed or Captive Market in Doosan Group

Who is Doosan Mobility Innovation?

2020

Market & Product Expansion
- Oceania & Europe & Asia markets
- 1.5kW Powerpack Module
- Recruiting more drone makers and other mobility partners

2019

Begin sales in Oct.
- Launched in Korea, US, China (2.6kW Powerpack and Drone)
- 120min / 5kg(11lb) payload
- Co-developing with 7 different drone makers

2018

2kW Proto Development Completed
- 120min Flight with 2.5kg payload

Soft Launching at Interdrone

2017

0.5kw Proto Development completed
- 150min Flight without payload

Established in Dec 2016

Mobile Application

Drone

UAV

Cart

Forklift

Flying Car

AGV & Robot

Skid-steer loader

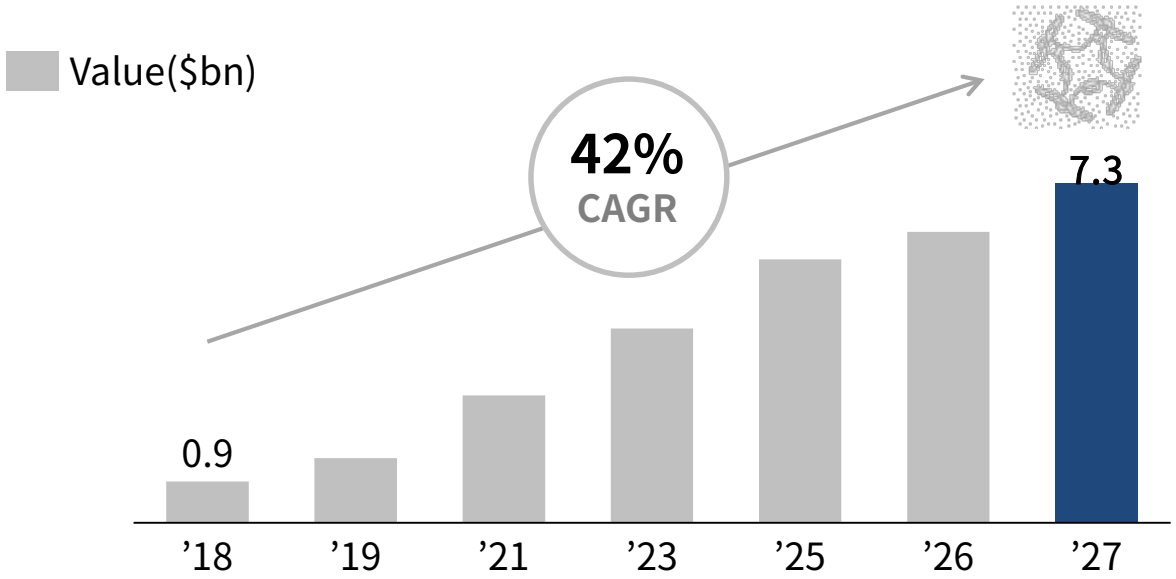
2-Wheel Vehicle

Portable Generator

Compact Equipment

Commercial Drone Market Forecast (Manufacture only)

Commercial drone market to hit **$7.3bn** by 2027



HFC drone market is expected to reach
$1.3bn in 2025

The number of Commercial drones is estimated to be
1 Million units in 2027

$7.3bn
in 2027
-Manufacture only

TEAL GROUP CORPORATION

$13bn
In 2020
-Manufacture & Service

Goldman Sachs

$39bn
in 2024
-Manufacture & Service

DRONEII.COM
DRONE INDUSTRY INSIGHTS

$140bn
in 2020
-Manufacture & Service

pwc

Top 4 Drone Application Forecast('24)

Delivery
$5.2bn

Agriculture
$3.8bn

Energy
$5.7bn

Construction
$5.1bn

Doosan's Existing Customer Access for Drone Application

Energy $5.7bn	Delivery $5.2bn	Construction $5.1bn	Agriculture $3.8bn



Doosan Heavy Industries

Doosan Industrial Vehicle

Doosan Robotics

Doosan Logistics Solutions




Doosan Engineering & Construction

Doosan Infracore


Doosan Bobcat

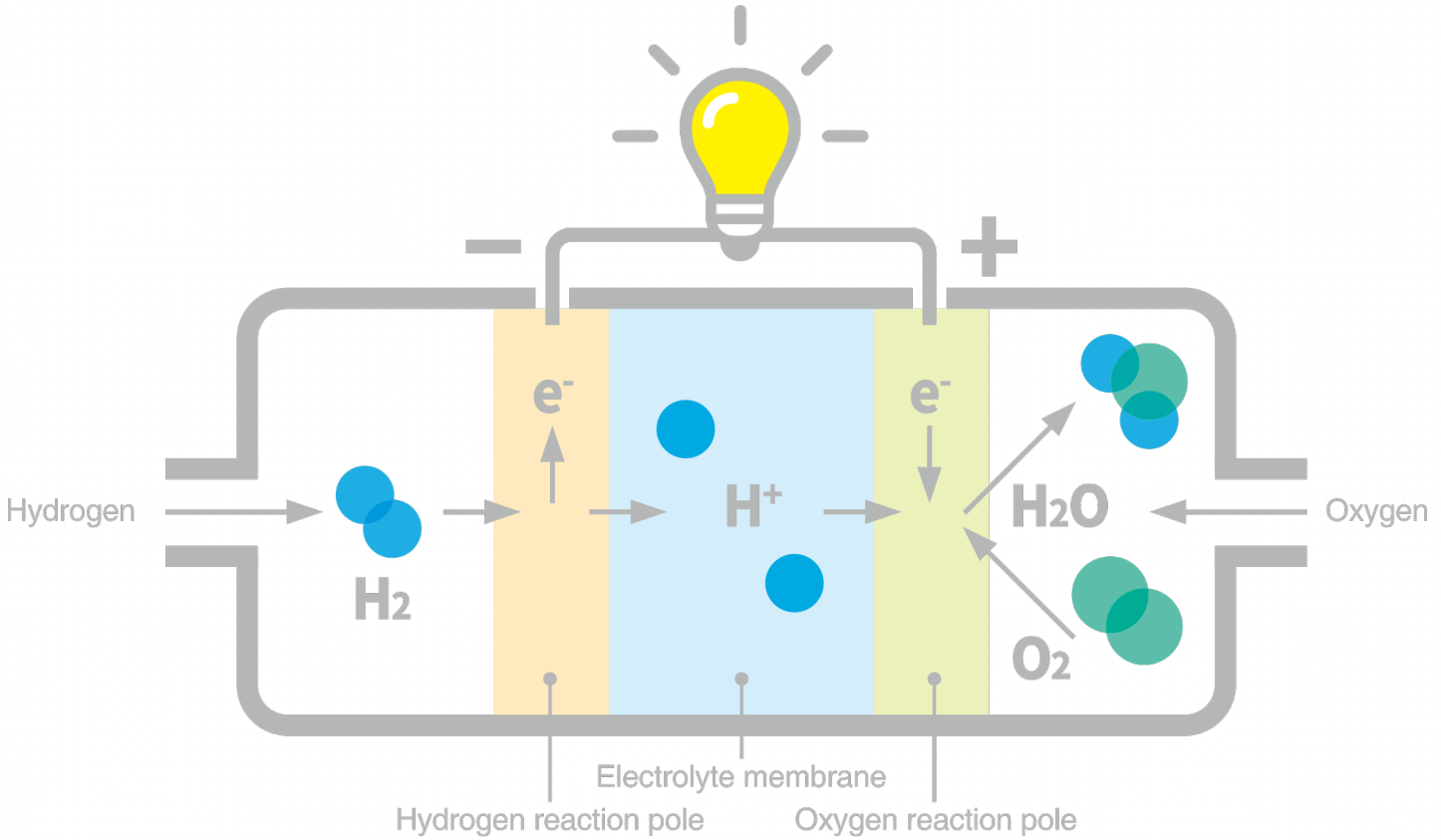

Doosan Infracore

Agri. engine

Chapter 2.
Understanding Fuel Cell Drones & DMI Products

Principle of Fuel Cell

Hydrogen, a natural element, is the new energy source for drones



How Power is Generated from Fuel Cells

Hydrogen fuel cell is the best option among energy sources for long endurance flight

2+ Hour Flight

Fuel cells have a higher energy density than batteries,
enabling two hour flights that is 4~5 times longer than batteries

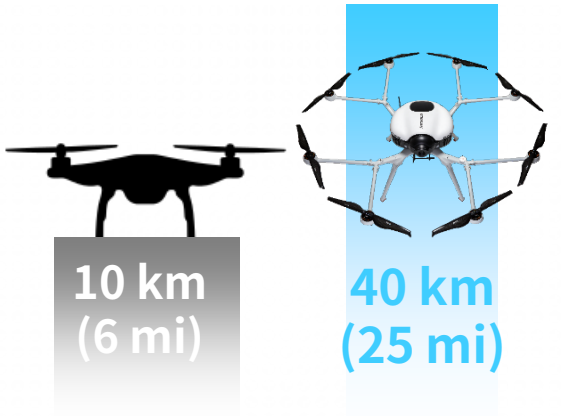
1000hr Warranty

DMI provides warranty period of over 1000 hours and real-time monitoring of product status is possible through DMI's remote system

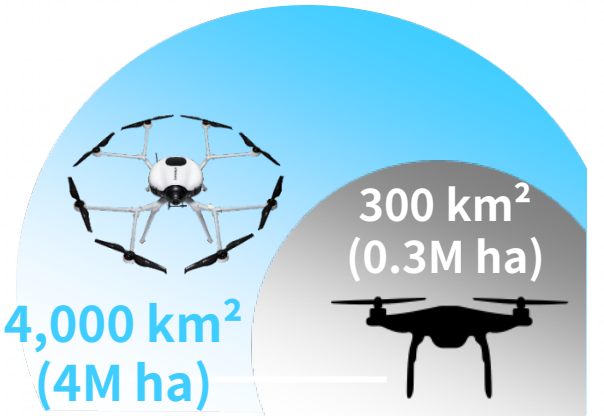
Easy to Use

Fuel cells are easily replaced or refilled with Doosan's hydrogen refueling network, and swapping tanks is a simple, quick process in the field

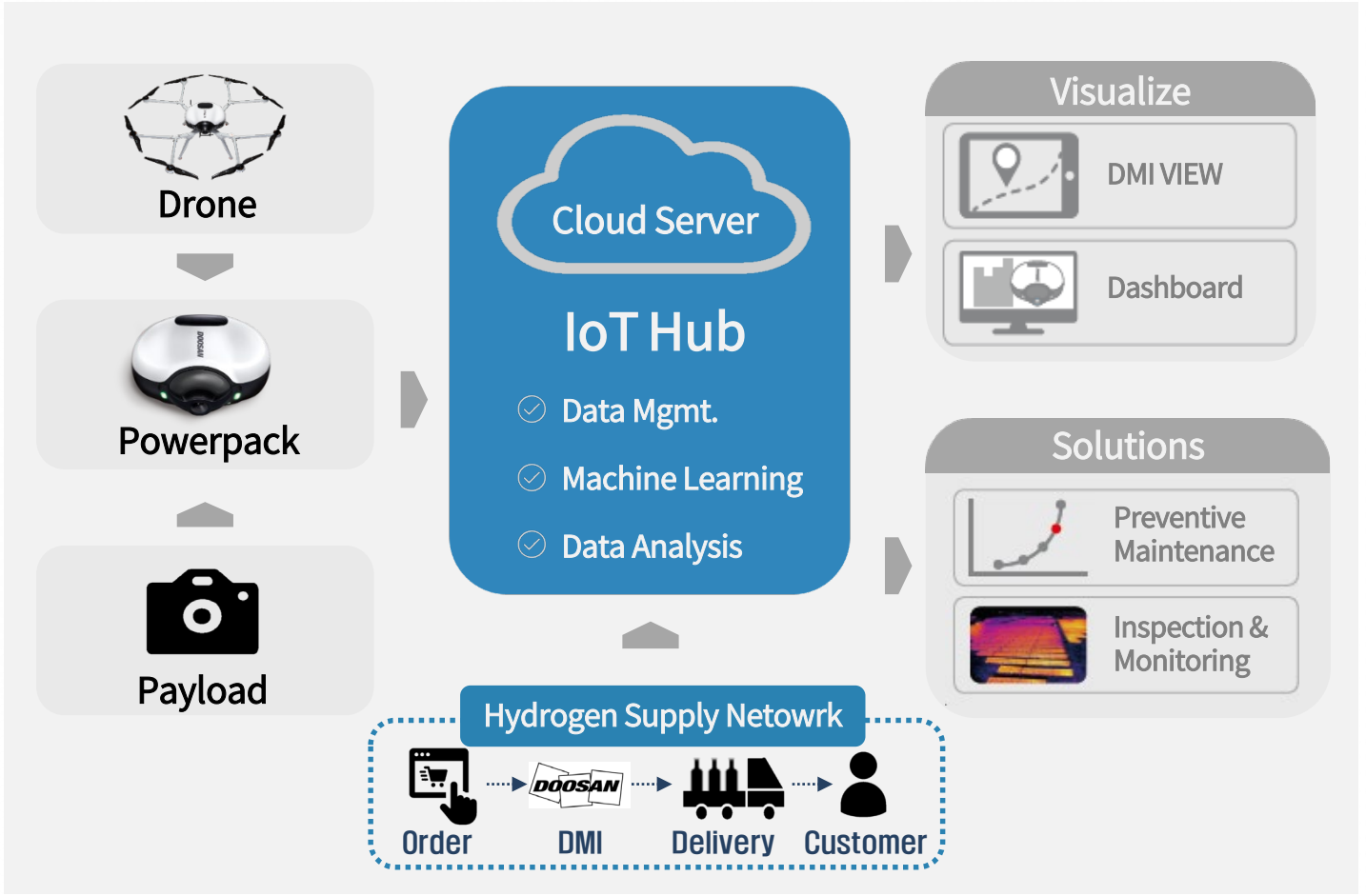
Monitoring Distance
(based on round trip)



Monitoring Areas
(based on round trip)



Total Solution Provider for long time flight: Doosan Mobility Innovation



1. Product line-up optimized for long flights

- Products guarantee up to 2 hours of flight and 5kg of payload

2. Remote monitoring & control based on LTE

- Able to monitor and control drones without limits of distance based on LTE communication

3. Solution service based on customer needs

- DMI digital platform provides right solution for customer's needs, including solar & wind power plant inspections and construction site monitoring

4. Smart hydrogen supply solutions

- Notify customers when to refuel hydrogen

1. Product line-up optimized for long flights

DP30

World’s first commercialized fuel cell drone,
applied to various applications that require a long flight

Rated Power: 2.6 kW

DS30

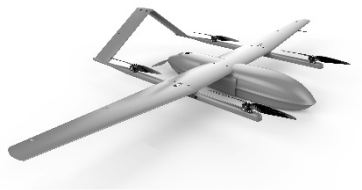
Optimized model for fuel cell powerpack

Max flight time 120 mins
Max payload 5kg

DT 30

Highly reliable model optimized for harsh industrial environment

Max flight time 110 mins
Max payload 3kg

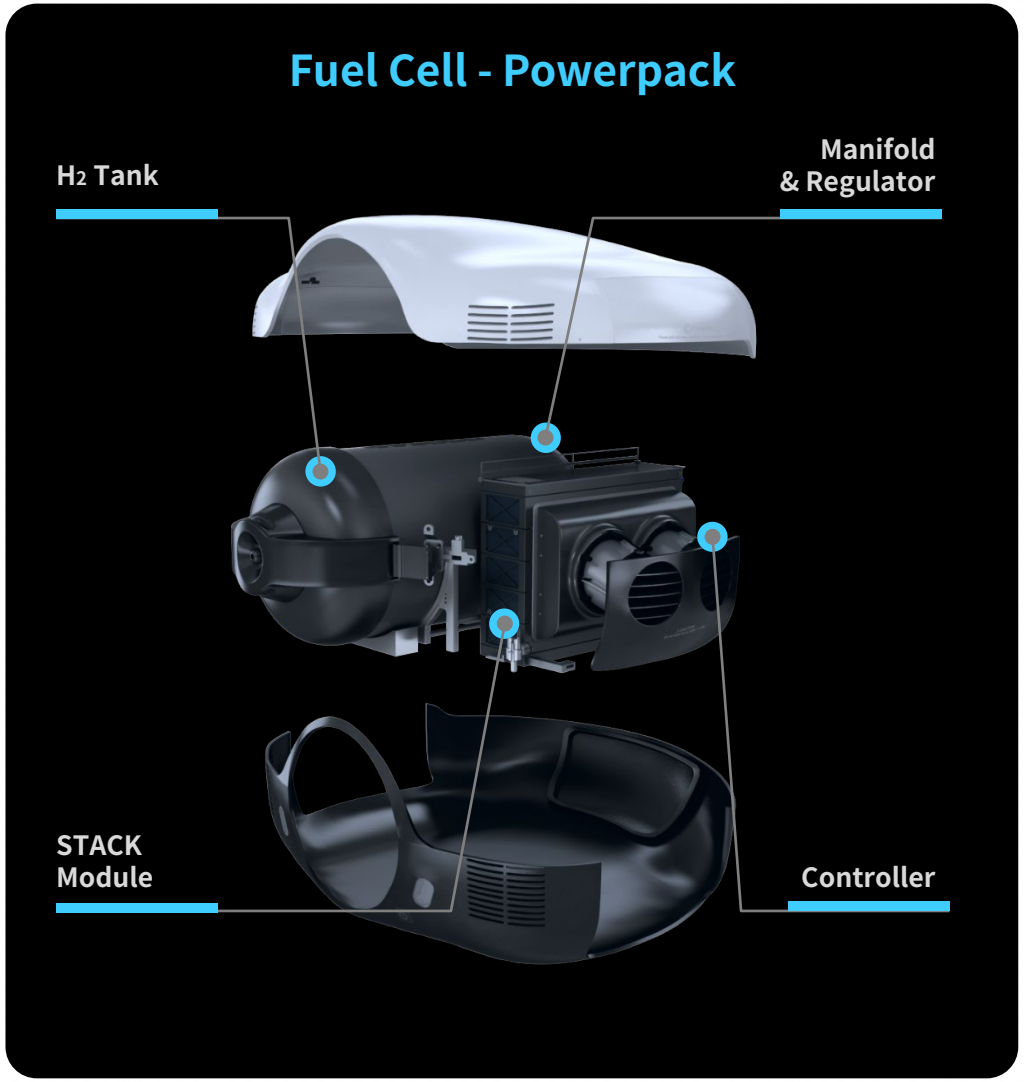


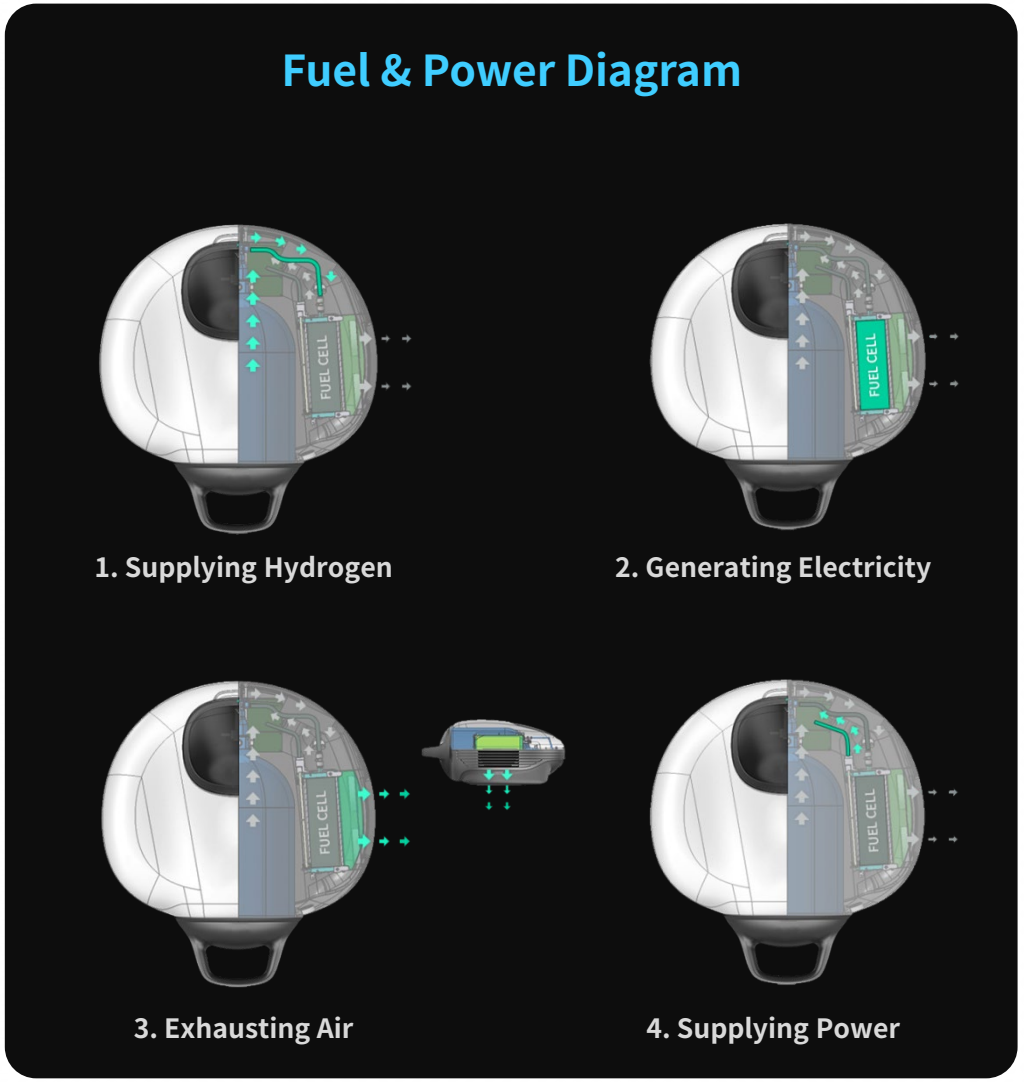
DJ25

VTOL model optimized for long flight

Max flight time 250 mins
Max payload 5kg

Structure of Fuel Cell Powerpack





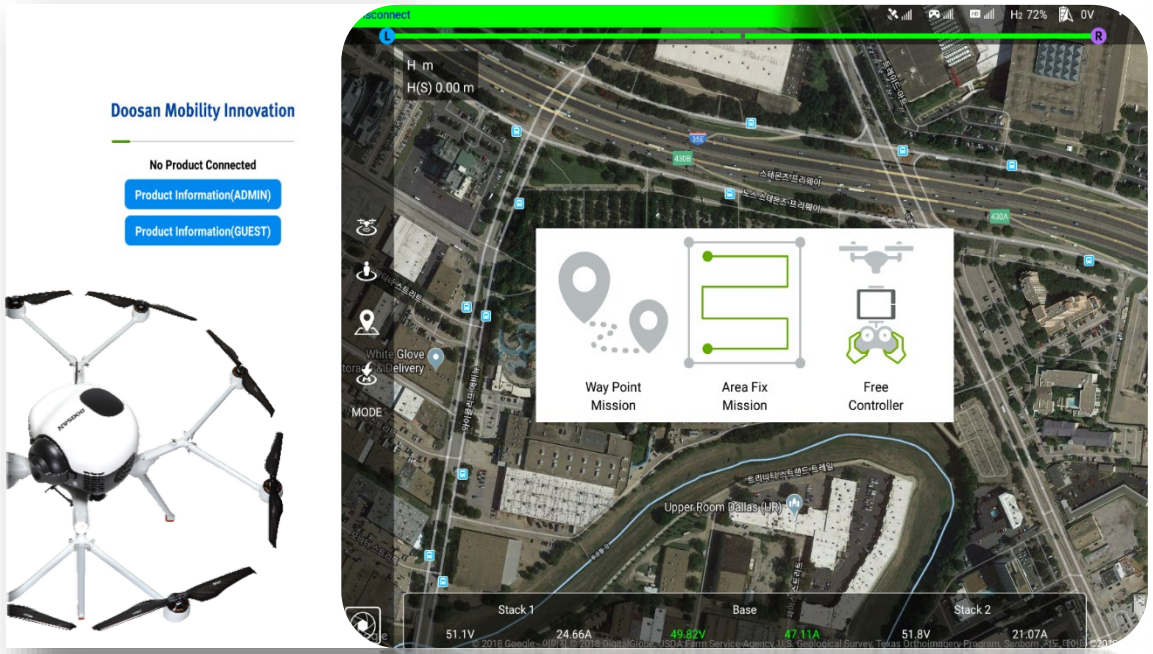
2. Remote monitoring & control based on LTE

Control station can control and monitor drones with DMI's GCS (Ground Control System) and DMI View (Digital platform) with LTE communication.

Web GCS

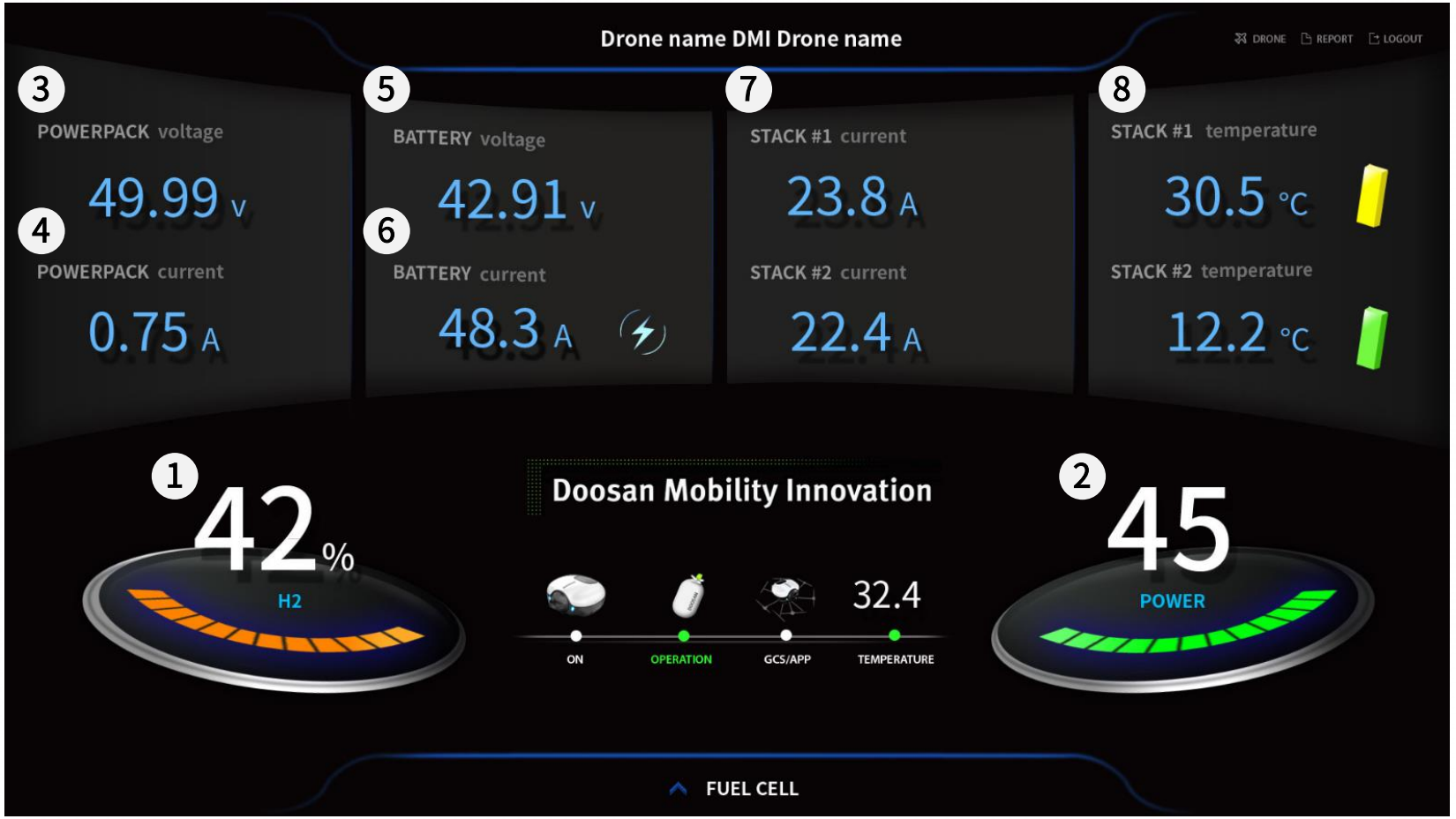
- ✓ Web base Solution without Installation
- ✓ 3D Map Base / Fleet Management
- ✓ Weather Cast Function

Mobile Application



- ✓ Autonomous Mission Flight
- ✓ Monitoring Sensing data in Real Time
- ✓ Monitoring Powerpack Status in Real Time

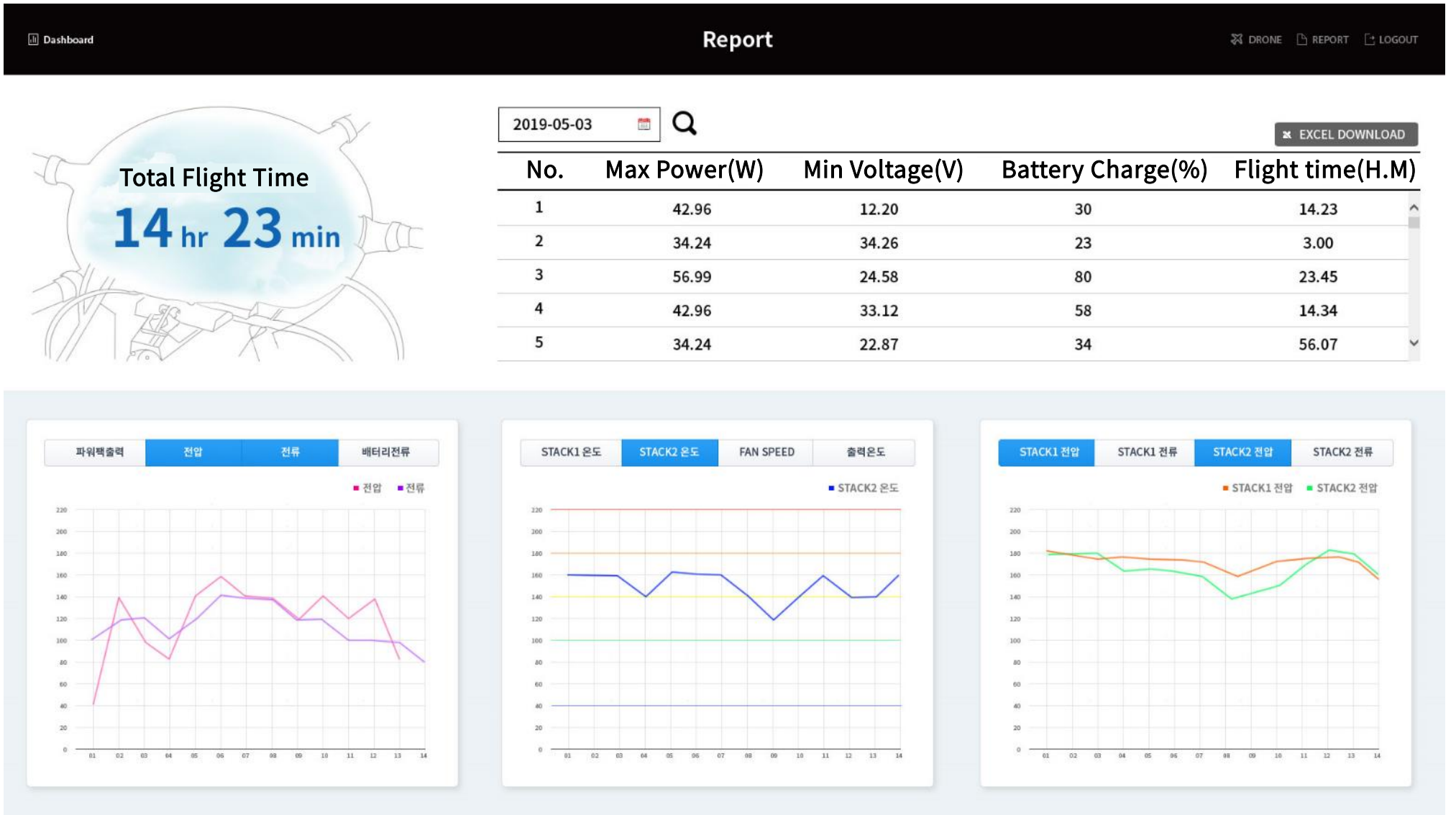
Real-time monitoring of powerpack status



Can check

1. Remaining amount of hydrogen
2. Consumption power
3. Voltage of powerpack
4. Current of powerpack
5. Voltage of battery
6. Current of battery
7. Current of each stack
8. Temperature of each stack

Flight report: Management of flight history

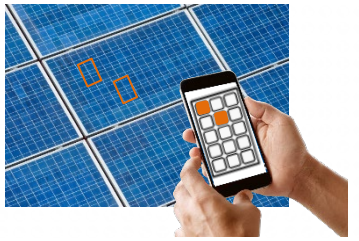
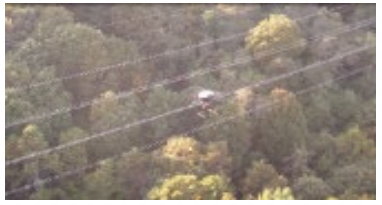
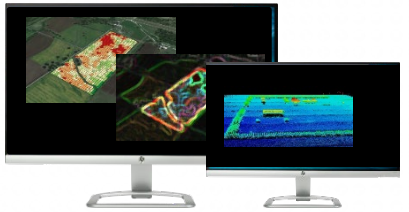


3. Solution service based on customer needs

Provider of end-to-end solution for long flight applications

Create End-to-end Solution with Partners

New Applications

	Mission flight	Data analysis	Solutions
Solar plant inspection			
Transmission line inspection			
Agriculture monitoring			

파트너사

DroneDeploy

PARAZERO DRONE SAFETY SYSTEMS

MFE Rentals

FORTRESS UAV

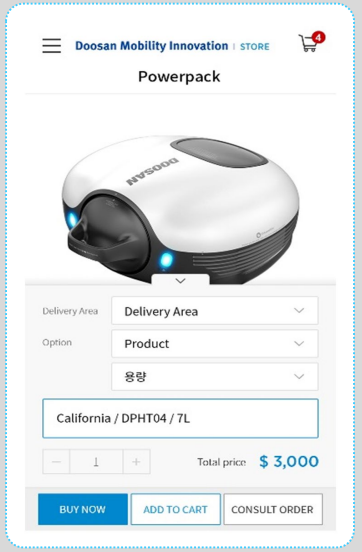
READYH2

RMUS Unmanned Systems Fleet Management™

Microsoft

4. Convenient hydrogen supply solutions

Easy order & delivery



- Simple order through web portal.
- Delivery filled tanks to the customer site and collect empty ones

Safe replacement of tanks

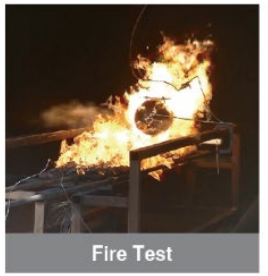
- Easily attachable & detachable hydrogen tanks based on quick coupler type
- Hydrogen tank tray for safe and easy storage

Safety proven hydrogen tanks

Safety Test


150M Drop Test


Penetration Test


Fire Test


Internal Pressure Test

Department Of Transportation U.S.A
DOT

Transports Canada
TC

Transfortable Pressure Equipment Directive
TPED

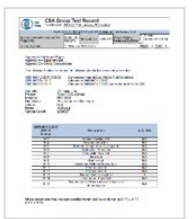
By 2020 June

By 2020


ISO 11119-3:2013

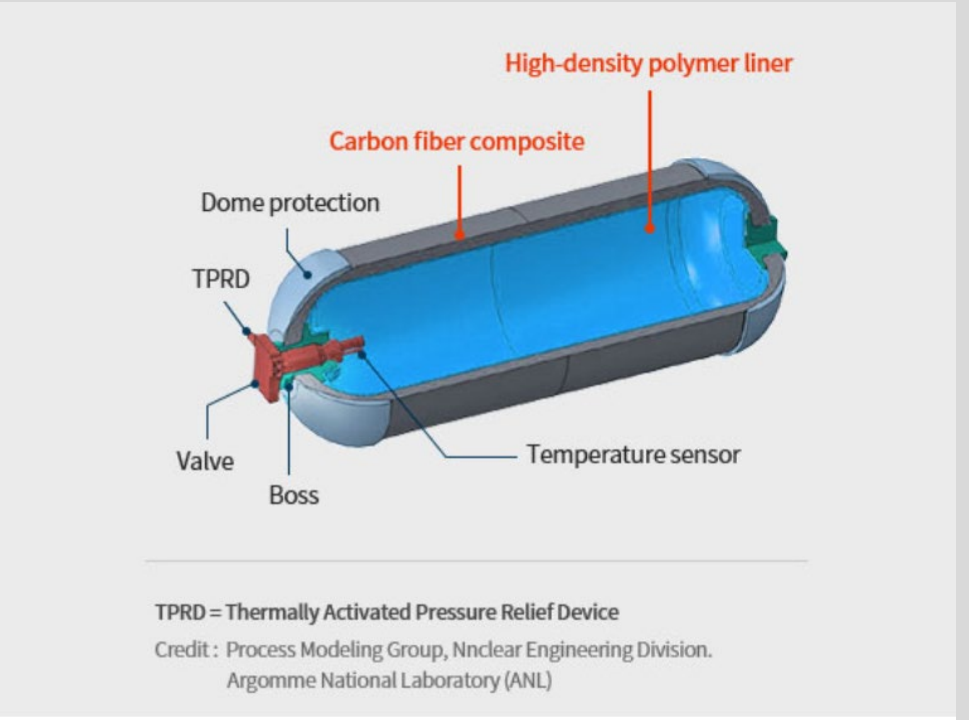
ANSI/CSA HGV3.1-2015

ANSI/CSA HPRD1-2013


ANSI NGV 2-2007


KGS AA311 2017

Structural Safety



TPRD = Thermally Activated Pressure Relief Device

Credit : Process Modeling Group, Nnclear Engineering Division. Argomme National Laboratory (ANL)

Certified

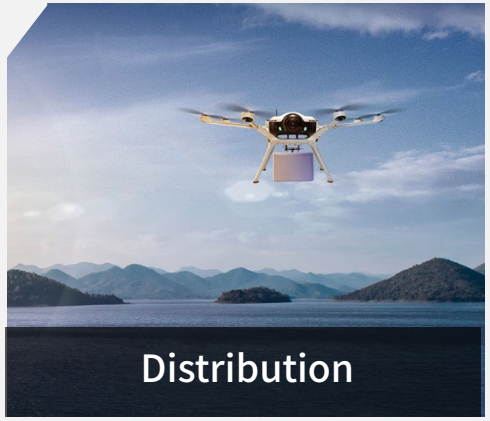
Light weight

Reliable

Safe

Chapter 3. Applications of Fuel Cell Drones

Needs for Long Flight(Application)



[USE CASE] Emergency Delivery _ Korea

Overview

- DMI delivered 15,000 masks to 3 local islands in Jeju with BVLOS flight, proving that hydrogen drones can be an innovative solution in CODIV19

Challenge

- Citizens in the 3 islands (Gapa, Mara, and Biyang), located off the coast of Jeju, are hard to get basic necessities including facials masks among CODIV19 because the infrastructure such as pharmacy is unavailable

Solution

- ① BVLOS flight based on hydrogen's long endurance and LTE monitoring range (No distance limitation for flight)
- ② Wind Resistance for Over-Sea Flight (Reliable flight in wind speed 10m/s)

Benefits

- DMI completed 4 round trips to and from 3 islands, covering 40km of distance, with 1 hydrogen tank without additional refueling.
- This figure implies that DMI's hydrogen drones can cover 13 times more area then conventional battery drones

Testimonial

"As there are no pharmacy or post office in Gapa Island, there were concerns about public mask supply. Now I can be rest assured with drone delivery."
- Won Heeryong, governor of Jeju Providence

[USE CASE] Emergency Delivery _ Africa

Overview

- DMI attended the Africa Drone Forum(ADF), and successfully completed a demonstration of emergency supplies delivery using hydrogen fuel cell drone in front of 70 potential customers.

Challenge

- Currently, only 34 percent of Africa's population resides within 2 kilometers of paved roads, making it difficult to supply blood in a timely manner due to the poor conditions of existing transportation.

Solution

- ① Longer Flight Time and Longer Distance (40km based on round trip)
- ② Higher Payload, with Temperature Control (5kg, customized payload)
- ③ Safety and Reliability (Real-time monitoring dashboard)

Benefits

- With 80km reachable distance, DMI drone can cover major cities in Rwanda based on Karongi
- Hydrogen fuel cell drones use abundant green energy, an opportunity to lower energy dependency in Africa

Testimonial

"Doosan Mobility Innovation's product is the only drone fueled with hydrogen fuel-cell. This is green technology and it stays in the air for longer time, enabling it to reach longer distance and get more economic values"

- George Mulamula, Worldbank

[USE CASE] Emergency Delivery _ USA

Overview

- DMI successfully completed a 43 mile flight between St. Croix and St. Thomas, carrying 40 simulation vials and health supplies, with 30 minutes of hydrogen remaining.

Challenge

- During the Atlantic hurricane season, the islands suffer from the lack of crucial supplies due to closed ports. Seaplanes have limitations, such as the cost and the rescue team's safety .

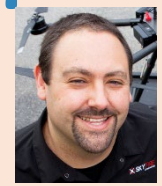
Solution

- ① Drones that Can Fly Longer Distance (23 miles based on round trip)
- ② Software for Safe and Reliable Flight (Web-based GCS system)
- ③ Payload Specialized for Temperature & Movement Control (5kg)

Benefits

- With autonomous mission flight and emergency landing setting, DMI drone can keep the pilot and the package safe.
- Hydrogen drone is affordable than jets, and are faster than boats (10m/s). With quick replacement of tanks, almost relentless flight is possible.

Testimonial



"The purpose of doing all of this was to enable the USVI Department of Health to provide more efficient services, test results and vaccines to the citizens of these islands. This win is a very important first step towards that goal."
- Matt Sloane, CEO and co-founder of Skyfire

[USE CASE] Emergency Delivery _ USA

Overview

- DMI has joined Search & Rescue (SAR) Forum 2020, cooperating with Verizon to broadcast high-definition videos and thermal imageries to detect survivors at sea in nighttime.

Challenge

- When the disaster strikes or when there are lost people in the sea at night or in a very foggy weather, longer and more stable use of visibility equipment is required.

Solution

- ① Longer Flight Time, Longer Monitoring (400,000 ha monitoring range)
- ② Sensors for Identifying Survivors (EO/IR dual sensor)
- ③ Software for Safe and Reliable Flight (Web-based GCS)

Benefits

- With drone monitoring, first responders can reduce the time of locating the survivors, and the cost of preparing medical supplement.
- With real-time broadcast for 2 hours of the disaster scene, command center can always react quickly on various circumstances.

Testimonial

"The limitation of conventionally powered UAS makes it very difficult to maintain persistent aerial surveillance. This hydrogen fuel cell powered UAS changed our response abilities significantly, nearly tripling our on-station loiter time."
- Jeffrey Schweitzer, Asymmetric Solutions Architect @ Verizon