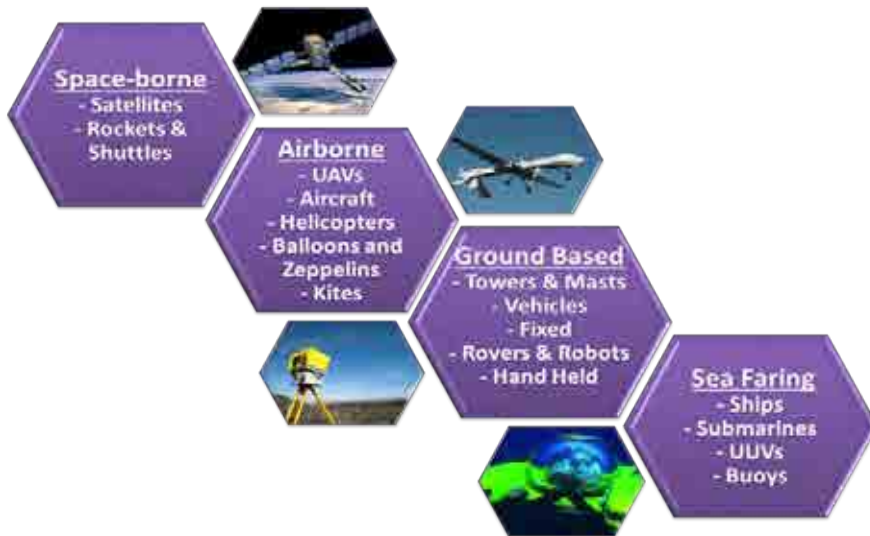


Drones / UAVs
Finding the Real Market Opportunities Beneath the Tsunami of Hype

Robin Higgons

Qi3 Ltd

Range of Platforms & UAV Types



Category	Sub Category
Long Range	<ul style="list-style-type: none"> • HALE (High Altitude Long Endurance) • MALE (Mid Altitude Long Endurance) • VTOL (Vertical Take Off & Landing) • Other
Mid-Range	<ul style="list-style-type: none"> • TUAV (Tactical UAV) • VTOL (Vertical Take Off & Landing) • Other
Short Range	<ul style="list-style-type: none"> • SUAVs (Small UAV) • MUAVs (Micro UAV) • VTOL (Vertical Take Off & Landing) • Other



Source: Domino's Pizza, Inc.



Source: Air-Technology

Early Commercial Markets

- Agriculture
- Environmental Research
- Security
- Transport
- Media

Some Emerging Markets

- Freight - transport of urgent spares
- Energy - power distribution inspection
- Oil & Gas - pipeline inspection
- Minerals - geo-physical surveys
- Telecoms - mobile base stations
- Mining - mine site management
- Disasters - situational awareness
- Natural Resources



Source: Unmanned.co.uk



Source: Green Aviation Ltd

Example - Drones & the GIS Sector

- ***Benefits for Photogrammetry***
 - Higher resolution images
 - Higher frequency
 - Lower cost
 - “Reaches the Places Other Platforms Can’t”
 - Independent of ground conditions
 - Quick
- ***Limitations***
 - Meta-data
 - On-board Data Management & Storage
 - Communications / data download
 - Range (generally limited to line of sight)
 - Flight time
 - Power availability

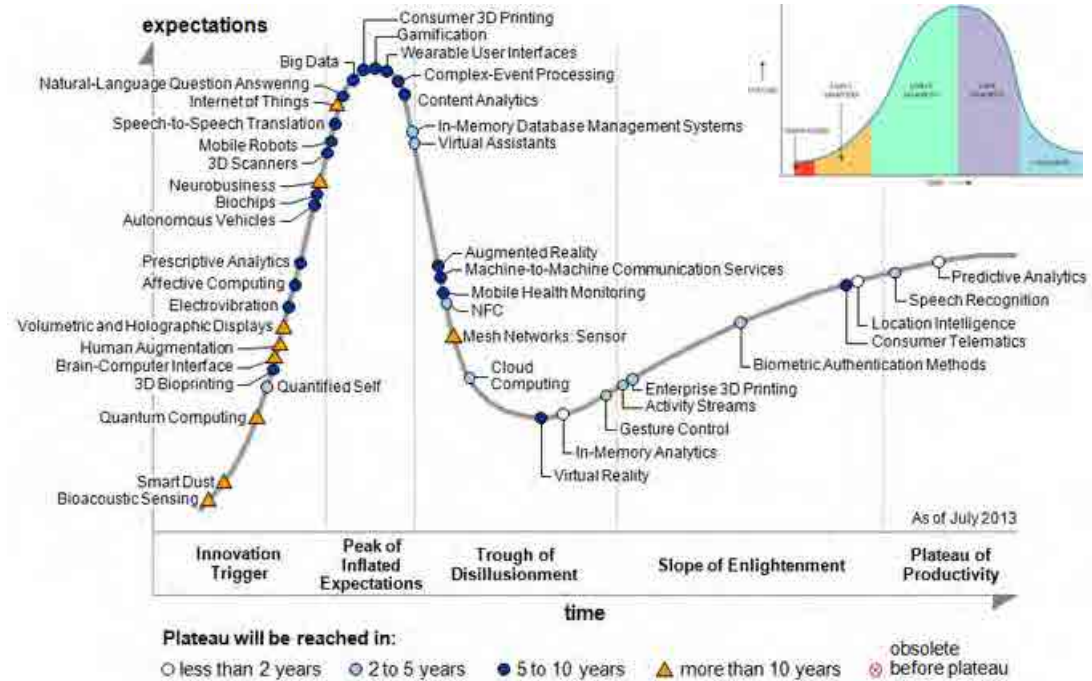


Setting the Scene

Qi³

Constraints

- **Regulations**
- **Public acceptance**
- **Technological capability**
 - Airframe and Sensing
- **Lift Capacity**
- **Metadata**
- **Competition (Direct & Indirect)**
 - Low Barriers to Entry
- **Business Models**



Key Factors for Short / Mid-term Success in the Drones Market:

1. Minimise “Cost of Failure”
2. Meet Market Needs Fully
3. Develop a viable Business Model

Minimise “Cost of Failure”



The Challenge

- CAA Mission - “To enable the safe, efficient and sustainable use of airspace and its supporting infrastructure.”
- Safety = “Cost of Failure”

Potential Solutions

- Long-term trials to prove reliability (many years)
- New technologies for collision avoidance / navigation / autonomous operation
- Select markets / applications where cost of failure is minimal:
 - Agriculture
 - Remote regions
 - Maritime
 - Antarctic???
- **Key is to work with the Regulators, making it easy for them to approve markets**

Markets / Applications - Emerging

- Medicines (Deutsche Post Trial – Norddeich to the island of Juis)
- Parcels Amazon setting up division in Cambridge
- Disaster Relief U.N. Agencies & NGOs in Tacloban, Philippines
- Emergency Spares British Antarctic Survey
- Military Supplies US Army

Markets / Applications - Future

- Logistics (DHL) Urban First and Last Mile
Rural Delivery
Intra-logistics

Markets / Applications – Game Changer Technology Advances

- Heavy Lift VTOL UAVs 200 – 3000kg
- Combined VTOL + Normal Flight

Current Status of Drone Systems

- **Mono-task Drones**

- Crop Spraying
- Imaging Drone
- Lidar Drone
- Hyperspectral Drone

Existing

Existing

Emerging

Nascent



Photo: Joe Proudman/UC Davis

- **Multi-task Drones**

- Military Drones
- Malaria & Disease Control Drone
- Multi-sensing Drones

Existing

(sensors + payload)

Emerging

Nascent

(medium payloads)



Drones and the Media

- “FAA Clears Six Film Companies to Use Drones”



Drone Applications in Forestry

- **Aerial Photograph**
 - Aerial photography for ortho-rectified Images
 - Photogrammetry for quantitative measurements
 - Multispectral data for surface & vegetation canopies
 - Hyperspectral data for mapping forest health:
- **Microwaves (Radar)**
 - Underlying soil characteristics.
 - Forest structure and moisture content
 - Canopy species discrimination
 - Digital elevation models & tree heights
- **Lidar**
 - Tree height determination
 - DEM (Digital Elevation Model)
 - Tree density & Volume estimates
 - Stocking density
 - Forest structure



Drone Applications in Precision Farming

RGB Camera

- Establishment/canopy cover
- Nitrogen status
- Maturity
- Height
- Lodging

Thermal Infra-red Camera

- Stress: insect, pathogen, water
- Stomatal conductance
- Canopy architecture eg Flag leaf angle

Hyper-spectral Camera

- Crop/canopy dynamics
- Nutrients status
- Various vegetation indices

Multispectral Infra-red Camera

- Anthesis
- Pests (aphids)
- Disease
- Weeds
- Nutrient status & Offtake
- Yield

Microwaves (Radar)

- Soil moisture.
- Crop structure and moisture content
- Digital elevation models

Lidar

- Crop canopy modelling
- Crop architecture & structure
- Yield estimates

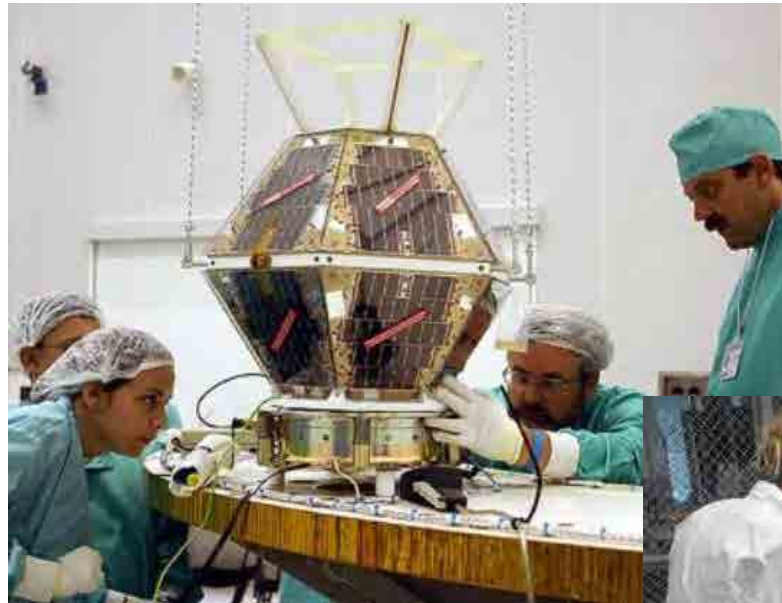


Images Courtesy of Rothamsted Research

Satellite Technology Convergence with Drones



EO Satellite
Source: Astrium



NanoSat
Source: Infoastro



Cubesat
Source: USC

Meeting Market Needs – Sensing & Surveillance



Remote Sensing Modality	Applications
Passive Microwave / Millimetre-wave	<ul style="list-style-type: none">➤ Soil Moisture & Temperature➤ Irrigation scheduling and management,➤ Floodplain delineation,➤ Drainage basin analysis➤ Snow Melt➤ Sea Ice Extent➤ Ocean Temperature➤ Precipitation➤ Meteorological Data
SAR and RADAR	<ul style="list-style-type: none">➤ Sea Ice Thickness➤ Elevation Mapping➤ Natural & Man-made Pollution➤ Shallow Ocean-floor Mapping➤ Land-use Mapping➤ Geo-surveying
THz and IR Imaging	<ul style="list-style-type: none">➤ Wild Fire Monitoring➤ Urban Climate Monitoring➤ Land Surface Temperature

Meeting Market Needs – Sensing & Surveillance

Qi3

Remote Sensing Modality	Applications
Hyperspectral Imaging	<ul style="list-style-type: none">➤ Crop Health➤ Pest Infestation➤ Forestry Management➤ Land Usage➤ Mineral Prospecting➤ Airborne Mineral Mapping➤ Environmental Impact Assessment➤ Pollution Assessment
LIDAR	<ul style="list-style-type: none">➤ Topography Mapping➤ Tree Canopy Mapping and Tree Heights➤ Biomass➤ Stand-off Chemical Analysis➤ Particulates➤ Water Depth➤ Oil Slicks➤ Chlorophyll
Gravity Gradiometer Magnetism	<ul style="list-style-type: none">➤ Geological Survey➤ Mapping underground features

Other Measurement Modalities

- Temperature
- Barometric Pressure
- Spectroscopy – UV / Vis / IR
- Particulates
- Humidity



Other Technology Requirements

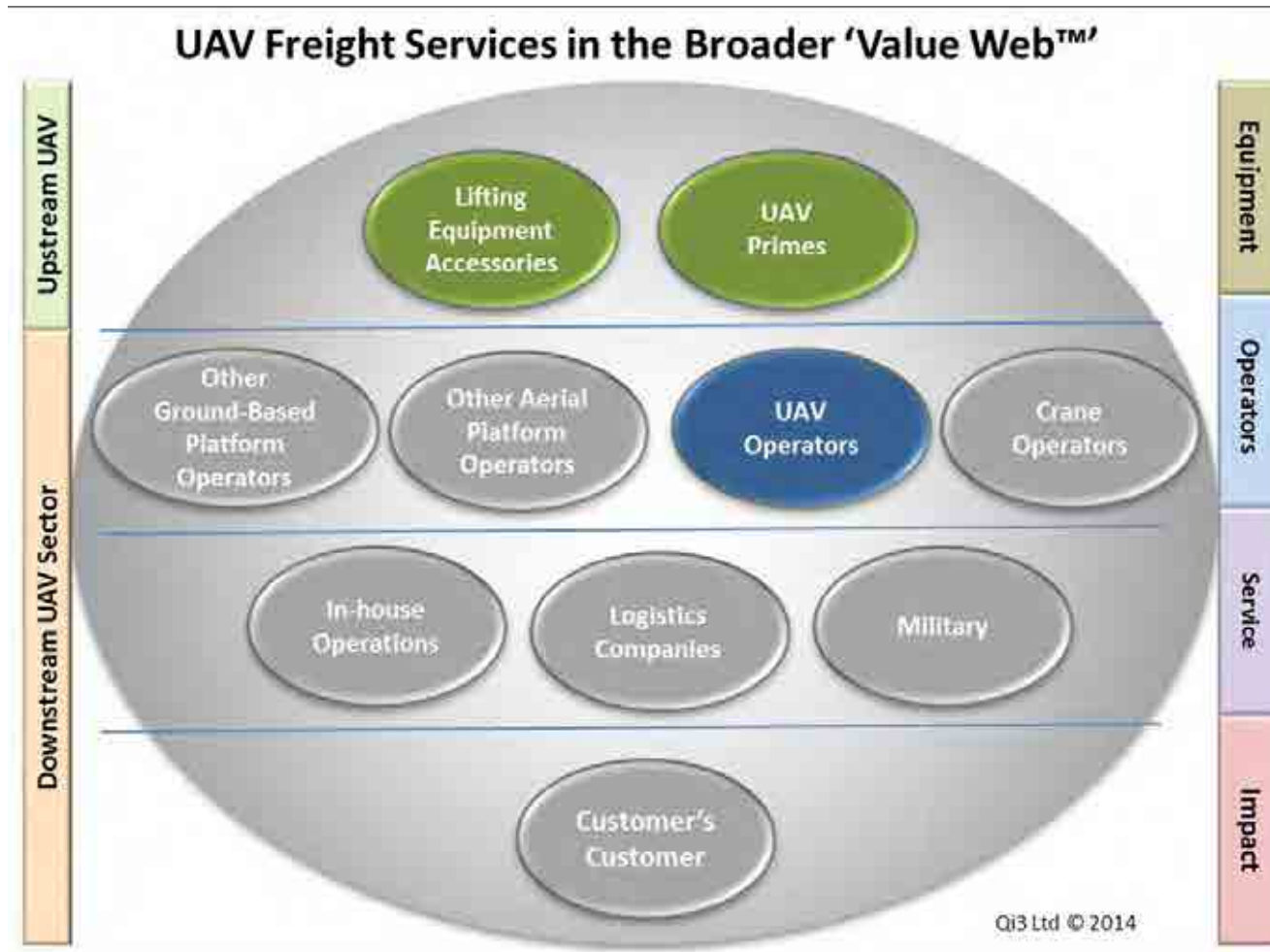
- Precision Navigation & Location - GNSS / INS
- Precision attitude / altimetry / distance
- Meta-data
- Data Synthesis / Interpretation / Presentation
- Autonomous operation

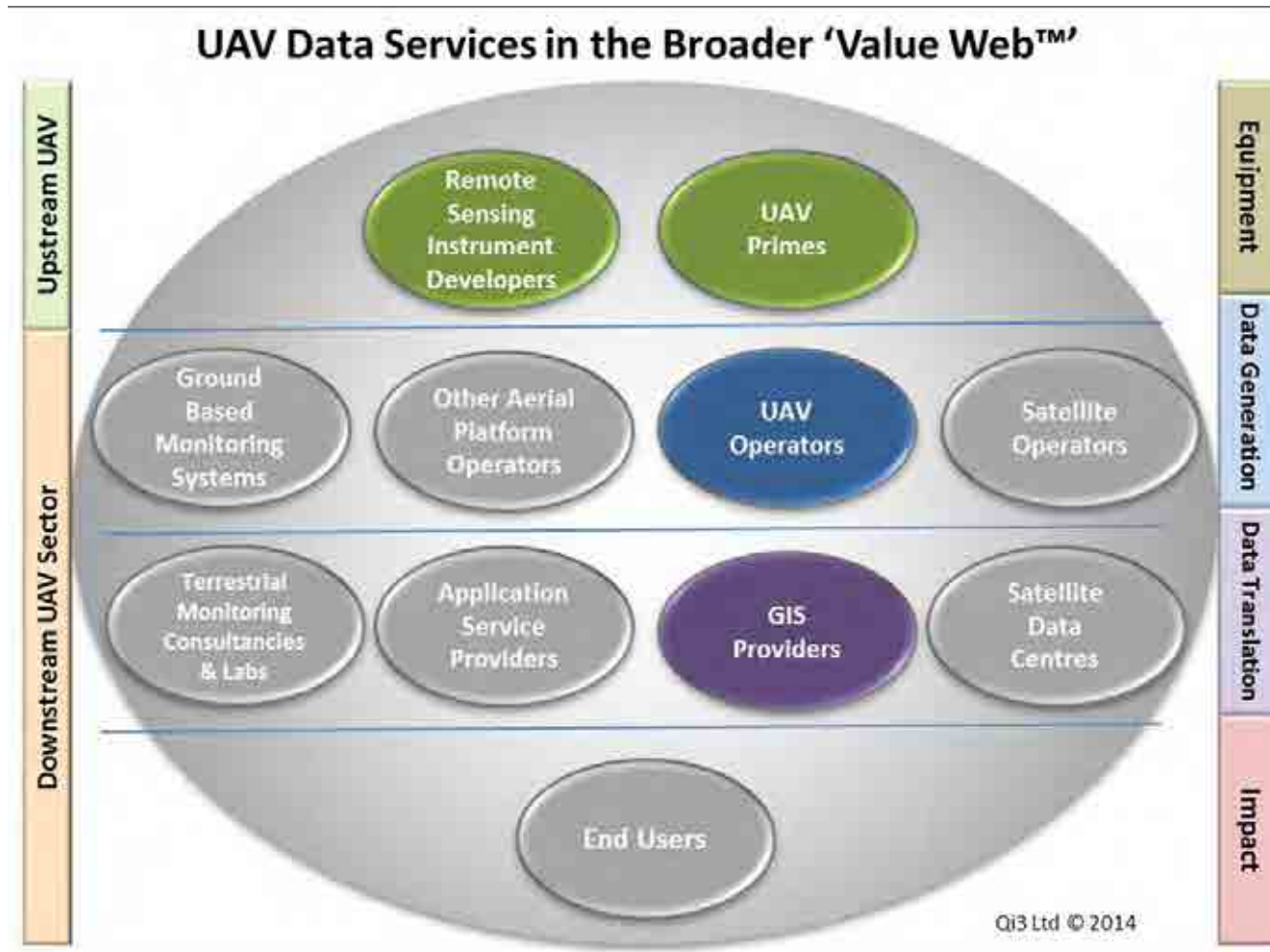


Remote Sensing Payload v Drone Size / Lift

Remote Sensing Modality	UAV Size Requirement	Reasons
THz and IR Imaging	Small	
Optical	Small	Depending on Resolution
Gravity Gradiometer Magnetism	Small	
Passive Microwave / Millimetre-wave	Medium	Dimensions
Hyperspectral Imaging	Medium	Dimensions / Power / Data
Atmos Chemistry	Medium	Power / weight
SAR and RADAR	Large	Power / Dimensions
LIDAR	Large / Small	Power





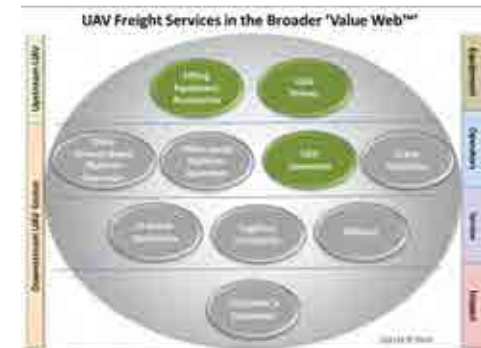


Business Model Options

- PC / Mobile **Open Technology Model**
 - Microsoft / Intel / Seagate / Dell / Google

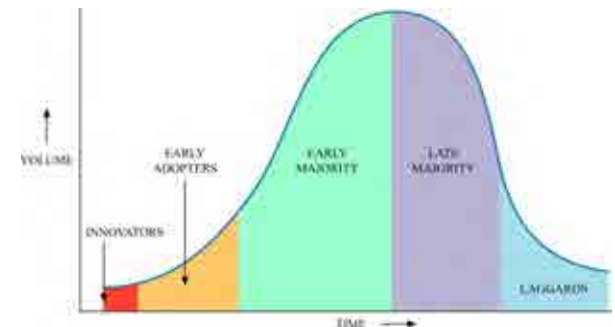
- PC / Mobile **Closed Technology Model**
 - Apple

- Oil Field Services **Closed Solution Model**
 - Schlumberger / Halliburton / Weathereds



For Suppliers & Customers Alike

- Focus on markets / applications / projects where “Cost of Failure” is low
- Properly understand market / application / project objectives and needs
- The market is for “**Early Adopters**”. Be prepared for development effort and compromises
- Understand business model options and select the “best for purpose”
- The technologies, market opportunities, customer needs, and regulatory constraints are moving very rapidly. Stay up to date.



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