

# SOFTWARE DEVELOPMENT PROCESSES

## Case Study – SkyDrop Drone Deliveries

### SUMMARY

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SkyDrop is a start-up business founded approximately three months ago. The founder has struck deals with a manufacturer of aerial drones, aviation regulators, local government, and a large multinational online retailer to commence a pilot program that will see drones deliver small packages to customers living in suburban Manchester by air. You are the manager of a newly-recruited team of developers tasked with creating the software that the company will need in order to operate from the ground up.

Your team will develop the company's back-end software, capable of monitoring the location of drones whilst in autonomous flight, identifying the GPS drop coordinates for each order based on its address or from the recipient's preferred drop-off location, and recording the delivery status of each package complete with proof-of-delivery photographs from the drone's on-board camera. Your team will also be responsible for creating a mobile app and website that recipients can use to track their delivery, specify exactly where packages should be dropped, and view the proof of delivery photograph once the package has actually been delivered.

The manufacturer of the drones is developing their software to allow the drones to fly autonomously. The drones themselves will be responsible for navigating from the depot to the programmed drop-off point, releasing the package, and flying home to recharge. This means that your team's system(s) do not need to consider route planning, obstacle avoidance, or the flight characteristics of the vehicles. You will, however, need to receive and record regular location updates from each drone to ensure that they can be located and recovered in the event of a malfunction or accident.

The company intends launching the service – with some considerable marketing – in 9 months. Your team needs to deliver a Minimum Viable Product (MVP) within this time-frame. The company has aggressive expansion plans, intending to open similar services in other UK cities if the pilot program succeeds. The company intends retaining the development team permanently to continue working on the software as the service expands, and to handle the maintenance of the system. You can adopt the software development methodology and techniques you consider appropriate, but the team will need to consult a significant number of stakeholders to identify and prioritise the requirements considered most important by the business.

## COMPANY INFORMATION

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The company has been founded by a local entrepreneur who owns several other businesses including several pharmacies that have long since offered a traditional road-based delivery service for medicines. She has secured the backing of an investment bank and several other private investors, with an initial round of funding around £2.5M. The business has agreed the purchase of 175 drones with options for a further 175 within the next two years if so required. The aircraft will be delivered in six months time, allowing three months for final flight testing and trial runs as required.

Manchester City Council (MCC) and the Civil Aviation Authority (CAA) have agreed to license the business as a pilot for autonomous aerial deliveries in the UK. The CAA are more willing to grant this kind of license in a smaller city with quieter airspace than, for example, London. Manchester City Council are keen to bolster the reputation of the city and its tech sector, and are keen to point out that the service will reduce the number of polluting petrol and diesel-fuelled vehicles on the road in the city. There has already been significant public and media interest in the business, which the company founder appears to have encouraged.

The company's founder and Chief Executive Officer (CEO) divides her time between her various businesses, and has appointed a Chief Operating Officer (COO) who will take charge of most day-to-day operations. The COO has appointed a head of finance and two junior accountants, and intends appointing an operations manager to oversee the fulfilment, customer service, and maintenance departments, for each of which the first staff members will also soon be appointed. The company also intends to hire a marketing officer, a Human Resources & Payroll coordinator, as well as a manager for the development team (you!).

SkyDrop is in the final stages of leasing a former warehouse and office on an industrial estate just south of the city centre in Wythenshawe. This site is considered ideal because of its location and its large delivery bay, part of which SkyDrop intends to convert into a suite of 9 landing pads immediately outside the building, accessible via a large doorway into the warehouse. The company also intends installing charging infrastructure that allows all 175 of the initially-ordered drones to be charged simultaneously, removing some of the operational complexity associated with charging. The building also includes ample office space, although some building work and refurbishment of these is necessary. The business is also installing state-of-the-art solar panels on the building's roof, which is expected to significantly offset the energy cost of powering the delivery service.

The COO estimates that it will take approximately 1 month for the office spaces to be ready to move into, and approximately three months to convert the former warehouse space into a suitable depot with two loading bays to receive packages for delivery, a charging and maintenance area for the drones, space and equipment for sorting packages, an area to program drones prior to take-off, and the landing pads outside. Once the office spaces are ready, your team will be able to work in the office, but the COO wants to ensure the project makes good progress before then.

## DRONE CAPABILITIES & SERVICE SCOPE

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The drones are battery powered and have a flight range of about 9 miles, meaning that deliveries will only be possible within an area approximately 4 miles from the depot (allowing for a journey of up to 4 miles each way, with some battery in reserve). On windy days (i.e. where prevailing winds are 15mph or more) this will be reduced to 3 miles, and the business has not yet decided on how this is to be handled. They may decide to only offer the service within a 3 mile radius at all times, or an arrangement may be sought with another courier to pass packages on where weather prevents drone deliveries to certain locations. The COO intends to make this decision in a meeting with the retailer, the marketing manager and you as manager of the development team. However, the marketing manager is not yet in post, and it will be at least 4-6 weeks before this meeting and decision can take place. Your team will need to plan their work around this area of uncertainty.

The agreement struck with aviation regulators allows the drones to be flown autonomously providing that they are only flown during daylight hours, they fly at an altitude of no higher than 400ft, and they are not operated within a prescribed “Flight Restricted Zone” covering an area around Manchester airport and the approaches for both runways [1]. The drones’ manufacturer has agreed to ensure that these restrictions are adhered to during operation. However, your team will need to ensure that packages are not dispatched for delivery within the Flight Restricted Zone as the drones will fail to deliver them and return to base, wasting time and energy.

The drones can only deliver small packages, with a maximum weight of 250g possible without reducing range. The release mechanism can only accommodate packages of up to 25cm (w) x 15cm (h) x 8cm (d), and the contract struck with the retailer ensures that only packages within these limits will be given to SkyDrop for delivery. The drones will only attempt to drop packages to the ground, and will not be able to attempt deliveries to balconies, roof terraces, flats etc. Thus, customers expecting packages who live above the ground floor will need to specify a suitable drop-off point at ground level, or choose another delivery service.

The agreement struck with aviation regulators allows the drones to be flown autonomously providing that they are fitted with FLARM transponders for collision avoidance [2], fly at an altitude of no higher than 400ft, and are not operated within the aforementioned Flight Restricted Zone [1]. Air traffic controllers at both Manchester Airport’s tower and at the National Air Traffic Service (NATS), have been provided with information on how to identify the drones if they stray into controlled airspace and the contact details for the depot so that a drone can be issued a “Land Immediately” instruction if they are considered to be interfering with other air traffic. The drone manufacturer will program the drones’ navigation software to ensure that they fly below this flight ceiling and navigate around the Flight Restricted Zone.

The drones are fitted with a wide variety of sensors and equipment to allow for safe and reliable operation. A GPS receiver provides accurate and precise positional data for navigation. LiDAR and cameras are used to detect obstacles and terrain. During flight, a FLARM transponder will broadcast each drone’s location and altitude to allow other aircraft to locate and avoid the drones [3]. An ultrasonic anemometer will be used to measure wind speed & direction, temperature, air pressure etc. whilst in flight. The drones also include a “belly camera” to record package drop-off, and a 4G modem which allows the drones to transmit their current location, heading, altitude and airspeed to the

SkyDrop depot. Your team will need to coordinate with the manufacturer to decide the frequency, format and back-end details for these transmissions, which SkyDrop will need to record. Drones will be programmed with the location to drop each package via Bluetooth at the depot, and your team will also need to work with the manufacturer to establish this process.

The drones are capable of some limited self-monitoring, and will be capable of “limping home” in the event of a single motor or propeller failure, abandoning any delivery in progress. Battery voltage and discharge characteristics are also monitored to identify battery packs nearing the end of their service life. This and other so-called “health” information will also be transmitted back to base in flight, and will be used by the maintenance department for both planned and unplanned maintenance on the vehicles. Your team will need to provide a mechanism for the maintenance team to view the health information of the drones to help them with planned maintenance. More severe malfunctions may cause the drone to land immediately, and will require the maintenance team to manually recover the vehicle, for which the maintenance team will need to be given a timely notification.

The manufacturer of the drones will retain control of, and be responsible for, all software running on-board the vehicles. This means that route planning, navigation, path-finding, collision and terrain avoidance will all be handled by the vehicles themselves. SkyDrop’s systems will only need to receive data from the drones whilst in flight rather than control them remotely during routine operations. The company will, however, be able to issue a “Return to Base” or “Land Immediately” instruction to a drone remotely, which will be sent to the vehicle when it next sends a status update. Your team will need to work with the drone manufacturer to establish the design of the protocol for issuing these commands and conduct field testing to ensure they work correctly.

## **PLANNED OPERATIONS**

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The Wythenshawe depot has a large delivery bay and warehouse space suitable for the loading, sorting and manual handling of small packages. Large tables are to be installed with suitable charging equipment for the drones during day-to-day operation, and a small workshop area will be equipped with spare parts (e.g batteries, motors, propellers) for the maintenance team to perform necessary maintenance on the vehicles. It is anticipated that, initially, the depot will handle approximately 2000-2500 deliveries per day, but with additional drones the CEO anticipates that this could readily be doubled should the business prove successful. The Wythenshawe depot should be able to handle this volume of packages and traffic comfortably.

With just a single large client and a modest initial number of packages to deliver, the CEO expects that the business will operate at a small loss during the trial period. If successful, however, the CEO projects that the Wythenshawe depot would be profitable with 4000-4500 deliveries per day, and subsequent depots would have lower overheads because of the existing software development work completed by your team, and the by-then established customer service team and maintenance capability.

Packages will be delivered to the depot each day between 07:00 and 08:00, with deliveries planned to start soon after 08:00. The agreements reached with the CAA and MCC prohibits autonomous flying of the drones after dusk, so deliveries will need to be completed and the drones returned to base quite early in the winter, with more time available in the summer. Your system will need to ensure that

drones have sufficient time before dusk to return to base after factoring in the travel time to each delivery location and back. One concern of the COO is that this means delivery capacity is effectively reduced in the run-up to Christmas, and this may require a larger fleet of drones in future years.

The company is installing 10GB Ethernet throughout the offices, with a small number of ports in the warehouse and maintenance areas such that computers can be located there if desired. The COO wants the company to host its back-end systems on cloud infrastructure to maximise availability, ensure that drones can always send status data via 4G, and to offer some resilience to a power cut at head office. To ensure that drones can be issued with a “Land Immediately” instruction if required even in the event of a power failure, you intend to offer this critical functionality via a laptop with a battery and 4G dongle in addition to the usual mains power and wired networking.

SkyDrop will require client-facing software to allow customers to track their delivery progress and view proof of drop-off photographs from the belly camera. Clients will also be able to select the exact drop-off location for their deliveries using a map and satellite imagery. The CEO & COO expect this to be accomplished with a web interface that works on both mobile and desktop devices. In addition, the contract with the retailer specifies that a delivery status and proof-of-delivery API will be created, allowing the retailer to integrate with both their back-end and customer-facing systems.

The company will also require internal software capable of monitoring the location, status and health of drones in the air, issuing “Return to Base” or “Land Immediately” instructions, viewing journey history for individual journeys, reviewing proof of drop-off.

## YOUR SYSTEM

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Although the requirements process for the system hasn’t even begun yet, some basic scoping information is already known. You are therefore aware that the system you’re creating will need to:

- Provide a means for packages to be scanned and tracked when entering and leaving the depot.
- Receive delivery confirmation and proof-of-delivery photographs from the drones in flight.
- Receive location and health data from the drones whilst in flight.
- Provide back-end software for SkyDrop staff to view location and health data for the drones whilst in flight, and to view the data for past deliveries.
- Notify staff in a timely manner if a drone suffers a serious malfunction and has to land, and provide location data to assist in recovering the downed vehicle.
- Provide a means to send “Return to Base” or “Land Immediately” instructions to drones, even in the event of a power and/or network outage.
- Provide an API for the retailer to obtain delivery status data and proof-of-delivery photographs for them to integrate with their own systems.
- Provide a public-facing front-end that allows package recipients to track the status of their deliveries, view proof-of-delivery photographs etc.
- Provide a means for users to specify a drop-off location for their packages, and a means to program the drones with the required drop-off location using their Bluetooth interface.

- The system will also need to verify that drop-off locations are at ground level, within the service range, are not within the airport Flight Restricted Zone, and that the delivery can be completed and the drone returned home before dusk.

## YOUR DEVELOPMENT TEAM

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SkyDrop hired you at the same time as hiring the development team, which means that you did not have any opportunity to influence the hiring decisions which were made on your behalf. The COO has recruited a diverse development team with a wide range of skills – all of whom are due to start work imminently. One exception is Alex, the most experienced developer on the team. Alex has two months remaining on their notice period with their previous employer and will start work at SkyDrop after working this notice period.

Your development team consists of five developers, plus yourself as manager. A significant portion of your role will involve meeting regularly with the COO, the operations manager, and staff working in marketing and finance. This means that your time for development activities will be significantly reduced. You will, however, be responsible for managing the project, deciding how the team works, and have final approval over the specification and design of the system. Some basic information about each member of the development team is presented below.

Because the development team is newly-hired there is no existing practice, process, or culture within the team. You will have to organise the team appropriately to be able to manage the project, and establish appropriate working practices for the creation of a reliable system from the ground up.

<b>Alex</b> (Senior Developer)	Very experienced developer who was worked at several high-profile companies both in the UK and in America. Currently employed at a high profile international ride-sharing taxi company. Very experienced in C#, Java & Kotlin, but some experience in Typescript, JS and Ruby. Seems to have no interest at all in management or mentoring.
<b>Cara</b> (Developer)	Previously worked in industrial automation using C, C++ & LISP. Returning to work after a career break of several years raising a child. Has previously managed a small team of developers on a larger project.
<b>Sajid</b> (Developer)	Three years experience as a junior developer for a marketing company, but this is his first time in the more senior role. Familiar with Java, Swift, Objective-C and currently learning Flutter.
<b>Temi</b> (Junior Developer)	Recent graduate from a local university, loves databases (both relational and NoSQL), but has experience mainly in C# with a little web development using PHP, HTML & JavaScript. Impressed at interview with good communication skills and seems like a good team player.
<b>Dimitri</b> (Junior Developer)	Completed a three month bootcamp from a local adult education provider, covering HTML & JavaScript. Has a promising portfolio of work and an obvious talent for front-end and design work. Came across as a little shy and reserved at interview.

## REFERENCES

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- [1] 'Drones', Manchester Airport. Accessed: Jan. 07, 2025. [Online]. Available:  
<https://www.manchesterairport.co.uk/aviation-professionals/drones/>
- [2] 'The practical collision warning system.', FLARM. Accessed: Jan. 07, 2025. [Online]. Available:  
<https://www.flarm.com/en/>
- [3] 'Solutions to minimize the risk of drone collision', FLARM. Accessed: Jan. 07, 2025. [Online]. Available:  
<https://www.flarm.com/en/drones/>