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The T5 Project

Single Terminal Occupancy Change (A)

Case study

Reference no 308-310-1

This case was written by Dr Nuno Gil, The University of Manchester, Manchester Business School. It is intended to be used as the basis for class discussion rather than to illustrate either effective or ineffective handling of a management situation. The case was compiled from published sources and generalised experience.

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The T5 Project: Single Terminal Occupancy Change (A)

“The world’s most successful airport development”

The view over Heathrow from the executive room in the BAA’s Business Centre was mesmerizing in that early morning in May 2003. On the eastern side, long- and short-haul aircrafts were uninterruptedly landing and taking off. On the western side, between the two runways, 2,000 workers and plant looked incredibly busy in a site as large as Hyde Park building the Terminal 5 (T5), a £4.2bn (2004 prices) project to expand one of the world’s most congested international airports over 260 hectares (**Exhibits 1a,b**).

T5 encompassed a series of major projects including three terminal buildings connected underground through an inter-terminal train, over 60 aircraft stands, a new air traffic control tower, a multi-storey car park, and key extensions of the existing transportation network to the new terminal campus. It aimed to increase Heathrow’s throughput capacity around 30 million passengers per annum (mppa), 20m in the first phase and further 10m in the second phase. The first phase started in the end of 2001 after a 4-year long public inquiry approved the planning application. The project was expected to be completed by March 2008 when British Airways – the major occupier of the new terminal campus – would begin the summer flying schedule. The completion of the second phase, which included the third terminal building, was scheduled to happen sometime around 2012-15.

Tony Douglas, the T5 managing director, was attending a corporate board meeting to discuss whether BAA, the airport operator and project manager, should instruct to the design teams a major change to the T5 functional and operational briefs, termed the Single Terminal Occupancy (STO). T5 had been conceptualized under the assumption that British Airways (BA) would only move part of its existing Heathrow operations in the first phase, but BA had recently expressed interest in moving all operations to cater for about 27m passengers in one go in 2008, a “once-in-a-lifetime opportunity” as described by the BA chief executive officer. Operating under a single roof would help BA compete with other European rivals operating from modern hubs because it would cut on costs and greatly ease the movement of passengers and baggage.

From the point-of-view of BAA, STO meant that the airport service standards about providing pier service for at least 90 per cent to 95 per cent of passengers in each terminal would need to be relaxed because a number of passengers would have to be coached until completion of the second phase¹. Yet, STO was attractive because it would release “some space on the chess board” earlier than expected, which BAA could remodel to provide new competitive terminal facilities to other airlines and meet demands for a guarantee of parity. It was hard, however, to foresee the impacts of the rework stemming from instructing STO – any schedule or cost overrun would have major financial penalties and severely damage the reputation of BAA in the marketplace.

¹ Coaching occurs when an aircraft is parked remotely from the terminal pier because a jetty stand is not available, and passengers have to be bussed to or from the aircraft.

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BAA plc.

British Airport Authority plc. (BAA) was a private airport operator company privatized by the 1986 Airports Act and listed on the International Stock Exchange, London, since July 1987. The operation of airports was a regulated industry in the UK. The Civil Aviation Authority (CAA) was the prime airport regulator with the Competition Commission (CC) in an appellate role. The Airport Act prohibited the levying of airport charges at an airport subject to economic regulation unless permission by the CAA was in force in relation to the airport. Airport charges were connected with the landing, parking or taking-off of aircrafts. CAA granted permission to BAA levy charges in 1986 with a condition limiting the maximum amount of the airport charges imposed for 5 years from 1st April 1987. Every 5-year period or quinquennium, CCA required the CC to review BAA business and the formulae that set the maximum allowed airport charges. CC had to investigate on whether BAA had pursued a course of conduct which had operated or might be expected to operate against the public interest.

The quality of the service provided by an airport operator was measured through specific indicators, such as stand and jetty availability, availability of lifts, escalators and passenger travellers, cleanliness, lounge seat availability, and easiness of way-finding. In the aftermath of the last quinquennium review, BAA had implemented a service quality rebate scheme. Hence, BAA paid specified rebates to airlines for provision of services failing to meet agreed quality standards (e.g., serviceability of jetties, aircraft stands, people movers, baggage reclaim carousels, and time passengers spend in queues).

Airport charges represented about one third of the revenue for BAA — other sources of revenues stemmed from operational activities such as services that BAA provided to the airlines (e.g. provision of check-in desks and staff car parks) and to passengers (e.g. duty free shops, duty paid shops, banks, catering, car rentals, and car parking). BAA chose concessionaires through a process of bidding for turnover rents but, as CC observed ‘BAA exercised a degree of control over its concessionaires’ product lines more akin to a department store than that of shopping centre proprietor.’² In particular, WDF (a subsidiary of BAA) held the duty-free concession. Sales of duty free goods accounted for over one-third of retail revenue and duty free shops had the highest retail yield.

THE HEATHROW AIRPORT

Heathrow was the closest airport to central London, the fourth largest airport in the world for total passengers, and the world's busiest international airport with demand far exceeding capacity in 2001. It contributed to the British GDP around 0.8-0.9%. While Heathrow's planned capacity, without T5, was around 60 million passengers per annum (mppa) from 440,000 air transport movements (atm), it handled about 63 mppa from nearly 460,500 atms in 2000, effectively operating in excess of planning standards at the peak periods albeit off-peak capacity (CC report). Demand forecasts for Heathrow were likely to be in the range of 118-143 mppa in 2016 (**Exhibit 2**). Heathrow's last terminal to be built, Terminal 4, was

² Competition Commission (2002). *BAA plc: A Report on the Economic Regulation of the London Airports Companies*

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opened in 1986. In 2002, BAA paid a rebate of £5 mil at Heathrow, £3 per departing passenger, to fund the costs incurred by airlines for coaching passengers to remote stands³.

British Airways was the most dominant single user of Heathrow with approximately 38% of the runway slots and 40% of passenger traffic. Heathrow boasted a preponderance of business and long haul passengers. About one third of its passengers travelled on business and one third of total passengers transferred between flights. Operating most long-haul services from Heathrow had been a strategic aim spelled out in BA's Future Size and Shape Strategy launched in February 2002.

THE TERMINAL 5 PROJECT

BAA submitted the planning permission application for a fifth terminal at Heathrow in February 1996. It expected at the time to get the approval decision by 1997/8, but the public inquiry period lasted longer than expected⁴, and BAA was only granted government approval to develop T5 in November 2001, subject to specific conditions. The T5 programme was underpinned on the business decision that British Airways (BA) would be the prime occupier of T5 to guarantee its most cost-effective use and minimise inter-terminal transfer requirements. BAA agreed early on a 'Memorandum of Understanding' with BA. In the project mission statement, BAA stated that "we will implement the principles of the *Memorandum of Understanding* agreed with BA and work openly and constructively in the execution of a successful project." The programme vision stated that T5 should be "The World's Most Successful Airport Development", i.e. become a world benchmark in successful airport design and operation, and set world class standards in developing the property and retail potential of airport facilities. To deliver this vision, BAA selected an internationally-renowned architecture practice, Richard Rogers partnership, to develop a distinctive design for the terminal buildings and to keep the role of concept guardian throughout programme delivery.

Planning for T5 lasted 13 years until the project received government approval in 2001. In the early planning stages, a report called 2020 Vision was compiled to examine the major issues, trends, and changes that were likely to affect airport developments. The aim was to interpret information on future changes, offer future scenarios, and make foresight knowledge of experts accessible to the developers responsible for shaping the T5 programme brief. Several teams involving designers and engineers from BAA and BA investigated different aspects of the passenger journey through the future terminal campus. The outputs of these teams were visions on significant future changes affecting airport operations, such as reduction of the number of check-in desks in anticipation of ticket-less travel, refinement of the baggage handling systems, and new way-finding strategies.

³ CAA (2003). *Economic Regulation of Heathrow and Gatwick Airports, Service Quality, Statement of Standards and Rebates*

⁴ This understanding was shared by other entities: the Merges and Monopolies commission, for example, assumed in its 5-year review in 1996 that the Public Inquiry would conclude in 1997 and on-site construction would start in 1998.

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The scope of the T5 encompassed 16 major projects, including airfield (airport aprons and taxiways), baggage system, extensions of two railway lines from the Central Terminal Area to the T5 campus, one core and two satellite terminal buildings; an air traffic control tower, and an airside road tunnel. These projects were in turn subdivided in 117 sub-projects. The overall cost of T5 was budget at £3.1 Billion at 2002 prices, with a 20% budget contingency (£600 mil) to account for risks such as wage increases, planning, design, and construction failures, accommodation of changes in requirements, unsatisfactory supplier performance, and fraud/theft. The size of the programme was unarguably large for the project client – BAA equity was valued at £5.5 billion in the end of 2002. As BAA stated “T5 represents the commitment of almost £4 Billion to an extremely complex and protracted project, combining engineering and construction risk” (CC commission report 2002).

In the 2002 five-yearly review, CC recommended that BAA assets in the course of construction be subjected to a series of triggers relating programme progress to increases in airport charges per passenger⁵. Five triggers were implemented relating increases in Heathrow airport charges to the T5 programme, each trigger approximately equivalent to 2% of airport charges at Heathrow⁶:

1. Completion of the diversion of the Twin Rivers that flow through the site (by providing 3km of open channel) on 31st March 05.
2. Release of ten serviced aircraft stands and associated taxiways on 31st March 05.
3. Hand over the Air Traffic Control Tower for National Air Traffic Services (NATS) fit-out work to commence on 31st March 06.
4. Weatherproof the main terminal building (frame, roof, and façade complete) on 31st March 07.
5. Weatherproof the second terminal building on 31st March 07.

The T5 programme encompassed four delivery phases, programmed around a set of 70 ‘anchor’ or fixed milestones, the ‘70 by 07’, which T5 suppliers signed off to record their commitment to their achievement:

- Phase 00: improvement works undertaken prior to the government approval of the T5 programme for supporting airport operations (e.g., aircraft parking).
- Phase 0: works planned post a favourable decision by the government on T5 to be available before the T5 opening day for supporting ongoing terminal operations, such as the early release of aircraft stands and associated infrastructures (e.g., taxiways, access roads, and fuel farms).
- Phase 1: delivery of two partially fitted-out terminal buildings, a track transit system (TTS) connecting the buildings, aircraft stands, car parking, and rail and road links.
- Phase 2: delivery of a third terminal building, complete fit-out of phase 1 buildings, and extension of TTS and baggage systems to the third terminal building.

⁵ *Triggers are elements in the regulated price cap formula that reduce the maximum allowable charges where BAA has not achieved capital investment milestones on time (CC 2002).*

⁶ *CAA (2004) Decision on the Detailed Specification of the Capital Expenditure triggers in the Price Cap Conditions of Heathrow and Gatwick Airports*

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Due to the Planning Inquiry delay, BAA sought a reduction of the original design/construction T5 programme to open on 30th March 2008. The original programme, termed Outlook Programme, exhibited a total duration of 6 years, including a 7-month buffer period designated for 'Risk.' In the Spring of 1999, a major review resulted in a new 5-year Control programme, including a target construction period of 4 1/2 years and a 6-month period for trials, testing, and operational readiness. Unlike the previous programme, the Control programme did not include a buffer period for risk.

Risk simulations undertaken by the planning team at the time suggested a 75% probability that the programme could be delivered in about 5-years (**Exhibit 3**). To give assurance of delivering the programme in 5 years, the planning team recommended compressing the target construction period to 4 years. The planning team acknowledged, however, that some underlying assumptions in the Control programme were already challenging. In particular, the planning team expressed concerns that the Control Programme reserved only 11-months to complete 275,000 sqm of fit-out, and that the target concrete pour rate of 2,400 to 2,700 cm/day of concrete (previously 2000cm/day in the Outlook Programme) could be too difficult to accomplish. Still, a benchmarking exercise with other airport projects suggested that these targets were doable. Airport developments completed at the time, such as Pittsburgh and Hong Kong International Airports, exhibited production rates for campus construction in the range of 1,667 sqm to 7424 sqm per month. BAA was targeting a construction rate around 4,583 sqm/month.

To improve the robustness of its target programme, BAA decided to invest on several strategic approaches:

1. Invest on faster construction methods, like off-site prefabrication of plug-in modules for the building services systems (electrical, mechanical, and telecom).
2. Saturate work areas on-site by opening simultaneously more areas of work and increasing on-site workforce and truck movements.
3. Standardize design parameters, such as fixing floor-to-floor heights to allow for extensive use of modular construction and reduce on site fixing effort and time.
4. Fix design and develop detailed construction programmes for shell and core⁷ construction in conjunction with the site logistics team.
5. Involve suppliers in the programming effort to develop viable detailed programmes.

Further, BAA established a formal stage approval process. Stage approvals were the gateways through which sub-projects had to pass to move from one stage to the next by demonstrating that all the key stage deliverables had been satisfactorily completed. Four main stages were defined — development, definition, production design, and manufacture & assembly — separated by approval periods respectively termed A-day (inception), B-day (feasibility), C-day, and D-day (**Exhibit 4**). C-day approval was needed to move a project from the definition design stage into the production design stage. Likewise, D-day approval was needed to release the capital funding necessary to move a project from the production design stage into the

⁷ *Shell and core includes primary elements such as foundations, basement, façade, roof, steel floor plates, vertical service and circulation cores; and secondary elements such as plant and mechanical & electrical servicing systems, spaces and routing for the baggage system, lifts and escalators, and aircraft access provisions.*

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manufacturing, assembly, and construction stage. D-day approvals were only granted to teams after they developed a production execution plan exhibiting a high degree of design completion and price certainty, with indicative percentages around 90 to 95% based upon bottom up supplier pricing.

The Main Terminal Building

The main terminal building was one of the largest projects in the T5 programme (**Exhibit 5**). It was a massive building, 420m long and 160m wide, which boasted one of the world's largest single-span roofs and a glazed curtain-walling façade. The area inside - enough to fit 50-full-sized football pitches across five floors - contained over 100 shops, 60 escalators, a six-platform rail station, and 18 pier-served aircraft stands. In September 2002, the T5 project board fixed a number of design elements based upon a version of the traffic-mix operational brief developed in July 2000. This brief assumed a 20 mppa throughput in phase 1 and 30 mppa in phase 2. The objective was to allow the development teams to move forward into the production design stage.

The design fixities included the shape of the building envelope and the number of levels, primary space occupied by the baggage handling system, vertical and horizontal circulations for people and trolleys, location of plant and mechanical & electrical servicing systems, and provisions for aircraft access. Further, the brief allocated over 273,733m² of floor plate as follows: 56,563m² to shell and core functions, including 23,564m² for retail (shops, catering, support & storage), 9,714m² for BA Commercial Important Passenger (CIP) lounges, and 12,785m² of phase 2 unfitted space; 114,000m² to back-of-house space, including 71,024m² for baggage handling and 20,155 m² for retail corridor; and 83,779m² to passenger circulation areas, including 69,562m² for circulation and 14,217 m² for the rail station.

THE DESIGN CHANGE MANAGEMENT PROCESS

From the onset of the T5 project, BAA was aware that the programme requirements would have to change throughout delivery to preclude delivering a terminal campus that would be inadequate to the airline and airport business needs by the time of its opening. This was put bluntly by Fiona Hammond, T5 legal director:

“The idea of building £4 billion worth of infrastructure over 5 years when the business cycles move at a different speed and not going around the loop a couple of times because the client changes his mind is nonsensical and unrealistic. We need to narrow down the number of design alternatives to have enough fixity and get a budget approved, but we will not be able to get it right the first time — change is a fact of life.”

BAA divided uncertainty into *Design Evolution* and *Scope Changes*. Design evolution was an inherent characteristic of the programme delivery process and it encompassed all design changes that had no implication to the original programme scope. As a result, changes that fitted within the design evolution notion were not expected to follow a specific change control process. Designers should instead handle these changes as part of the delivery process and within contingency budget allowances for design activities. As put by BAA in the T5 agreement, the relational contract with the first-tier suppliers, “accommodating change and uncertainty is to be part of the standard delivery processes...evolving plans will therefore be a

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The T5 Project: Single Terminal Occupancy Change (A)

prerequisite. If a plan has to be revised so that objectives are met then this is a necessary process.”

In contrast, scope changes were defined as events and issues that changed the T5 baseline programme brief, a statement of the operational and facility requirements for all of the T5 outputs. (The *operational brief* described the strategy for facilities or activities in terms of objectives, goals, and usage, whereas the *facility brief* described the requirements needed to support an activity or operation in terms of adjacencies, design considerations, area requirements, and principal service requirements). Hence, scope changes had to be handled and comply with a formal change management procedure. This procedure started with someone issuing an Issue Request Form (IRF) or an Early Warning Notice (EWN) to explore the implications of potential change prior to its formal request. IRF/EWN could then lead to a Change Request Form if a funding need existed via a Change Order (CO), Study Order (SO), a Budget Transfer (BT), or a Project Leader Instruction (PLI). To acknowledge that late changes represented a significant risk to the ability to deliver the programme on time and within budget, change requests had to follow some rules: (1) decline scope or specifications changes after D-day; (2) Subject scope changes pre-D day to approval from the relevant project board; (3) Test non-scope and space changes generated by the project teams against the brief, and get them endorsed by the design managers where they impact the brief (**Exhibit 6**)

Three distinct forums could process, review, assess, and approve change requests: (1) a weekly forum at the project level facilitated by the change control manager and project leader; (2) a fortnight forum at the programme level to coordinate the introduction of changes generated by the main user airline; and (3) a monthly programme board review for recognizing and endorsing the changes that needed to be progressed to the programme executive and airport operator board.

Further, end-users could request 2 types of response: a fast-track review that provided an “extreme order of magnitude” assessment of cost and schedule implications within a 2-day review period; and a 14-day review that provided a detailed and co-ordinated assessment. Change approvals were granted by project boards for requests involving smaller sums, by the T5 executive committee for requests larger than £0.5m, and by the BAA board for requests larger than £30m. Available data suggested that change requests were taking about 30 days to receive an approval.

SAFEGUARDING

The principle of safeguarding for future change was spelled out in a specific strategic brief so as to reflect that “some aspects of the business will change as the T5 project develops and that other parts of the business will change post opening.” The development team had the role of ‘guardians of the principles of flexibility’ so as to recognize that ‘maintaining flexibility had to be done in a responsible manner to avoid waste and abortive costs’. The safeguarding brief spelled out that T5 ought to develop ‘design solutions that incorporated provisions for operational flexibility, expansion, and adaptability’. These provisions would help BAA to retain flexibility to economically provide for growth and change in the long term. In

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particular, the brief of the main terminal building listed the following set of operational objectives to safeguard for future flexibility:

Safeguarding Strategies for Future Growth

The brief recommended a *prudent* application of safeguarding strategies for future provision, including safeguarding the need to expand the main terminal building in the second phase and beyond as follows:

- Enable the provision of additional area by providing upfront some steel floor plates, yet leaving them sealed off and unfitted (i.e. without ceilings, floors, and building services distribution systems) until the beginning of the second phase.
- Enable the expansion of the CIP lounge: the cross-section profile of the floor plate should be designed to expand in the form of a 17,000 m² mezzanine. It should also allow for inserting escalators and trolley lift pits, without disrupting the M&E services zone below.
- Enable a future conversion of the 60-m baggage reclaim belts into 90-m belts, as well as the addition of more baggage reclaim belts to the International Baggage Reclaim Hall.
- Enable the provision of a separate security route to a separate airside CIP lounge for Concorde passengers.

Design Adaptability and Operational Flexibility

The brief recommended phasing delivery for requirements that were likely to change in the early design stages, as well as developing solutions that could economically adapt to change, including:

- Defer the design freeze of the floor arrangement drawings inside the main terminal building to a ‘last responsible moment’ towards the end of the construction programme so as to allow adaptation of the retail and check-in areas to late functional changes.
- Provide separate zones for distributing the horizontal building services so as to allow re-routing the services without needing to coordinate the holes in the structural beams.
- Provide an adaptable backbone concept for the mechanical and electrical systems based upon a system of three sets of vertical cores and prefabricated horizontal routings to accommodate evolution in the floor arrangement drawings.
- Use a hollow grid floor plate system (a steel structure with a concrete topping) so as to make it easier to core drill where necessary, as well as unobstructed floor plates so as to avoid ‘bookends’ in the passenger processing areas.
- De-link the elements of the building envelope (roof and façade) from the steel floor plate superstructure.
- Design the bridges and adjoining floor slabs in the area shown as a ‘void’ between the reclaim hall access bridges so as to enable the construction of floor plate and associated infrastructure to service an airside duty paid arrivals shop.

Tony Douglas was aware that about 23% of the work would be completed against the baseline plan in one month and that, by the end of the year, the work completed would have reached Dr. Nuno Gil, Manchester Business School, The University of Manchester, prepared this case as the basis for class discussion. The case does not intend to serve as endorsement, source of primary data, or illustration of effective or ineffective handling of an administrative situation. Specific data, names, and situations in the case may have been intentionally altered.

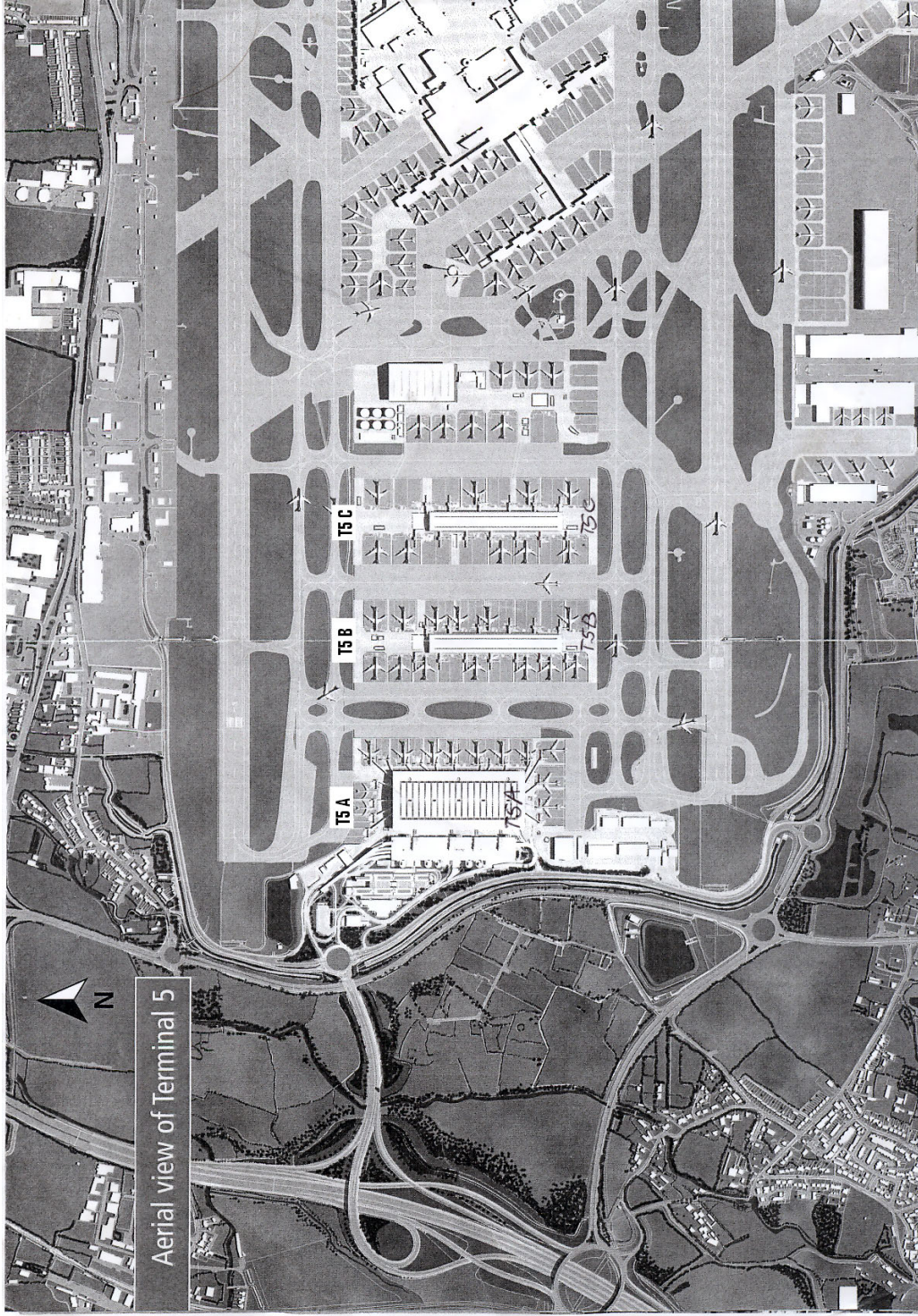
The T5 Project: Single Terminal Occupancy Change (A)

the 30% hallmark with spending exceeding £1bn and a workforce on site around 3,000 operatives and 1,200 support staff. Piling works for the foundations of the main terminal building had already started last November 02 after the D-day approval in October 02, and the whole substructure of the building would be completed by October 03. Further, many other D-days had taken place in May 03, including for roof fabrication and construction; steel floor plates; façade; lifts; and escalators. The D-day for the nodes and fixed links to the aircraft stands in the main terminal building was scheduled to July 03, and the D-days for the building services prefabricated units and baggage were scheduled respectively to September and October 03. The first ground bays of the main terminal were planned to be handed over to start erecting the roof in September 03. It urged a decision on whether to instruct STO to the design teams, and particularly to the team developing the main building. What should Tony recommend to the board?

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Exhibit 1a - Aerial View of Terminal 5



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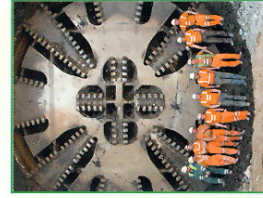
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Exhibit 1b – T5 Construction Programme

T5 CONSTRUCTION PROGRAMME

Terminal 5 is one of the largest construction projects in the UK. It is a huge and complex construction programme, phase 1 alone consisting of 16 major interconnecting projects and 134 sub-projects. It extends far beyond the construction of just a terminal building, including 41 aircraft stands, two satellites (one in phase 2), a 4,000 space multi storey car park, a new control tower, the creation of a new spur road from the M25, the diversion of two rivers and an airport perimeter road, and over 13km of bored tunnel, including extensions to the Heathrow Express and Piccadilly Line services.

A construction programme of this scale presents many engineering challenges made more complex by being next to a busy airfield.



The work encompasses Civil Engineering, Building, Highway Engineering, Mechanical & Electrical Engineering, Tunnelling, Railway Engineering, Specialist Systems Technology including a complex Baggage Handling System and a Track Transit System (people mover), and Project Logistics management. Each of these disciplines is represented by integrated teams of suppliers which contain designers, manufacturers, contractors and specialist consultants.

The T5 Programme of work is making extensive use of prefabricated components and building services modules. The manufacture of prefabricated components and sub-assemblies will be carried out in many locations throughout the UK and Europe.

The first phase construction of Terminal 5 is programmed for five years which can be broken down into five key stages:

Stage one: Site preparation and enabling works

This involves preparing the site for major construction activity. The work includes a very significant amount of archaeological excavation, services diversions, levelling the site and removing sludge lagoons, and constructing site roads, offices and logistics centres.

Stage two: Groundworks

This includes the main earthworks, terminal basements, connecting substructures and drainage & rail tunnels.

Stage three: Major Structures

These structures are the main terminal building (Concourse A), first satellite (Concourse B), multi storey car park and ancillary structures.



Stage four: Fit Out

Significant elements of the fit out include building services, the baggage system, a track transit system (TTS) and specialist electronic systems.



Stage five: Implementation of Operational Readiness

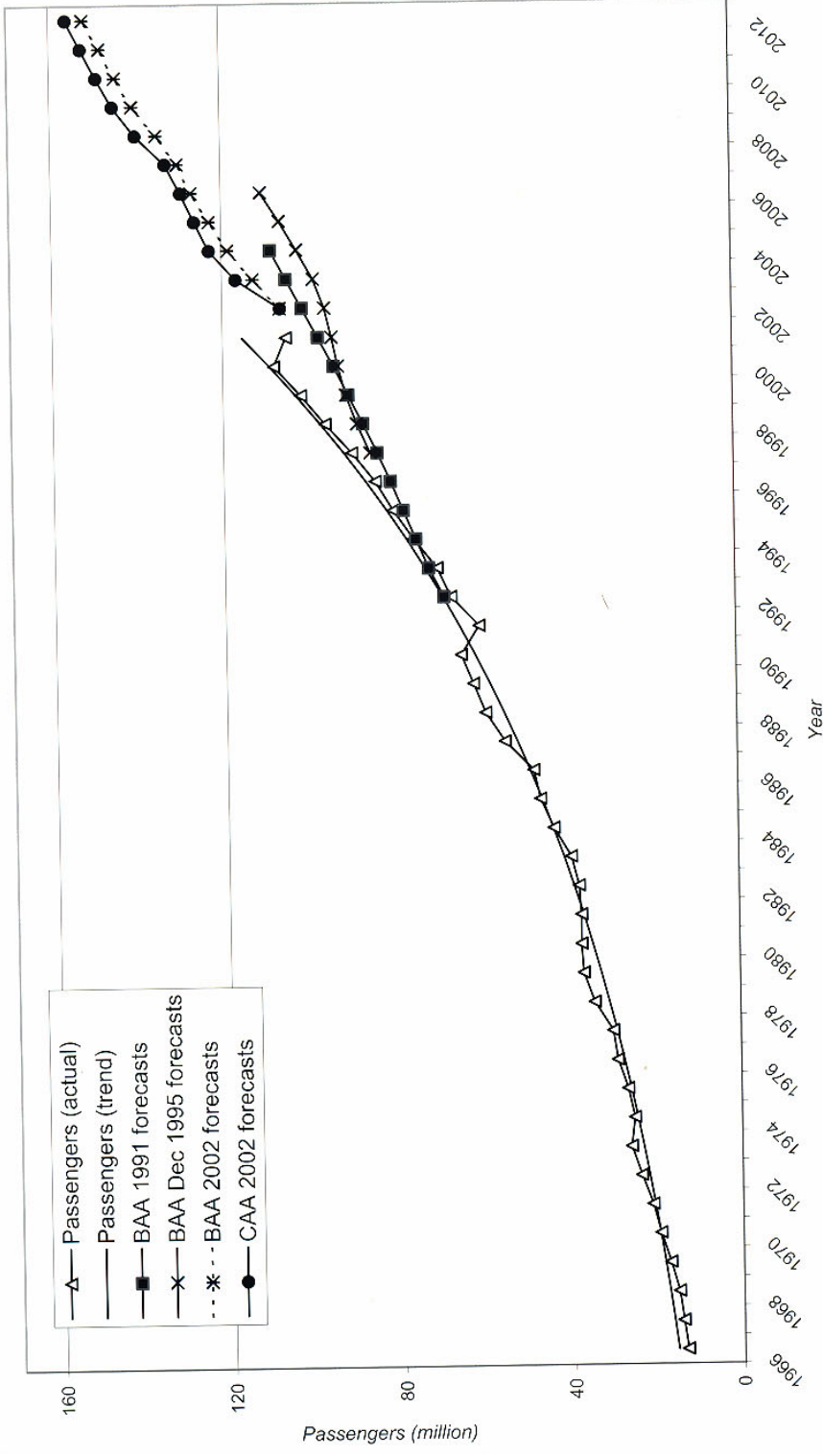
Operational readiness is necessary to ensure that not only is the new terminal 5 infrastructure (phase 1) fully complete but that systems are tested, staff trained and procedures in place, ready for operation in Spring 2008.

Phase 2, which includes a second satellite and additional stands will commence after 2006 when the residual site, where sewage sludge is still treated, will be vacated.



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 Exhibit 2 – Number of Passengers at BAA London Airports

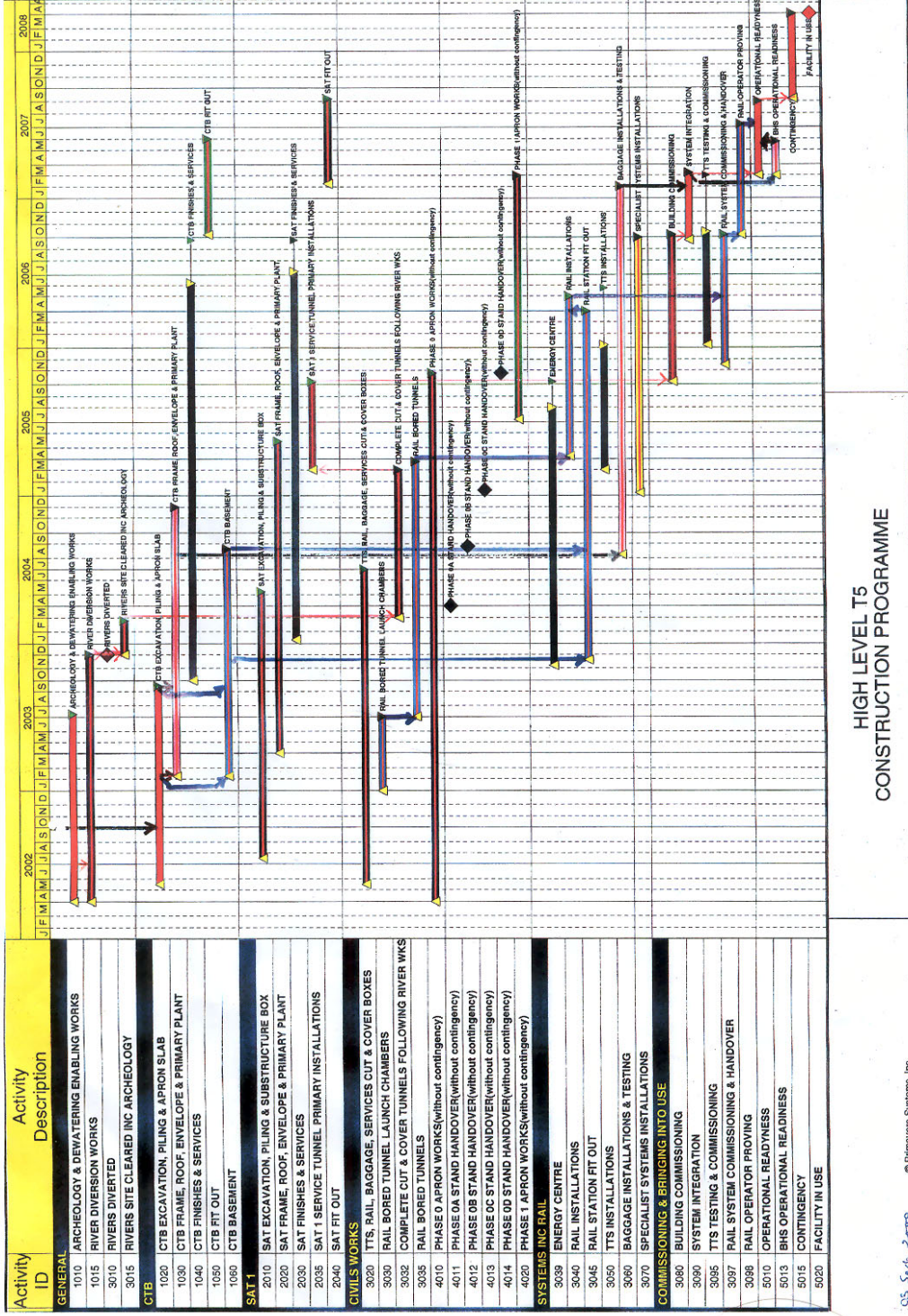


Source: CAA (actual passengers), ONS (GDP).

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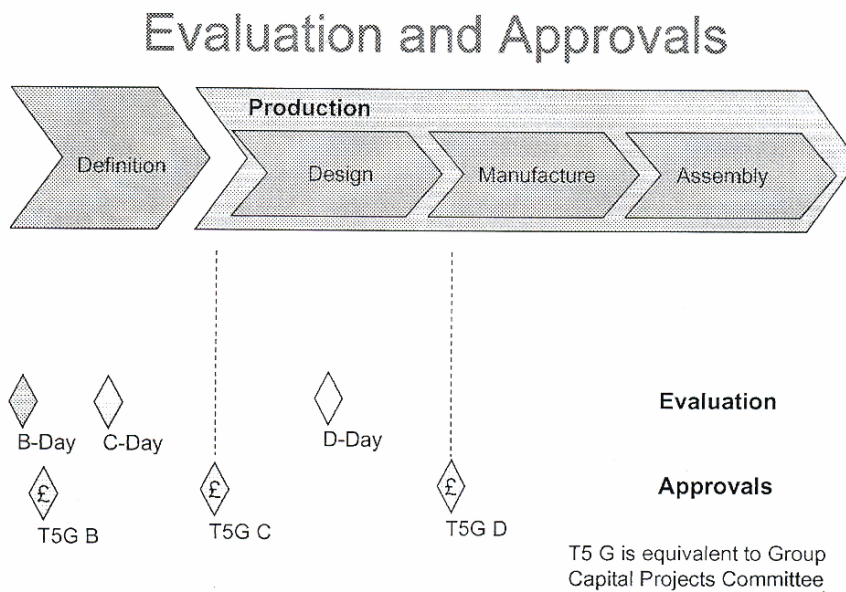
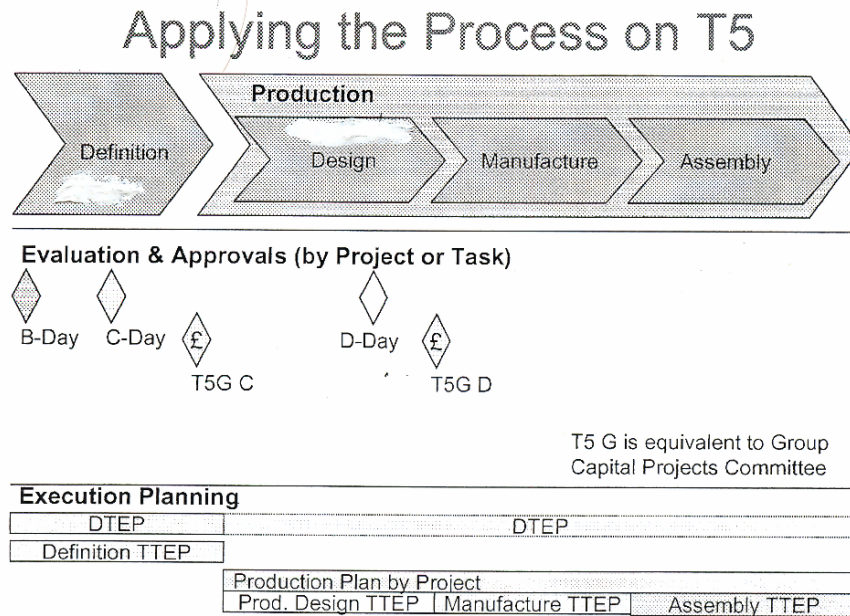
Exhibit 3 – High-Level T5 Construction Programme



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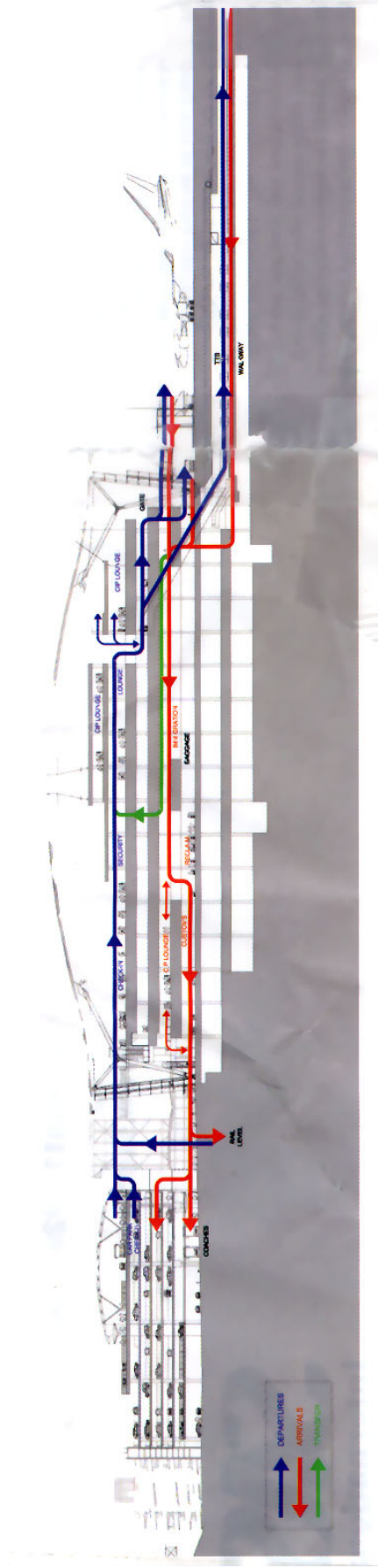
Exhibit 4 – Stage gate approval process



Dr. Nuno Gil, Manchester Business School, The University of Manchester, prepared this case as the basis for class discussion. The case does not intend to serve as endorsement, source of primary data, or illustration of effective or ineffective handling of an administrative situation. Specific data, names, and situations in the case may have been intentionally altered.

The T5 Project: Single Terminal Occupancy Change (A)

Exhibit 5 – Car Park and Main Terminal Building Cross-section



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