How to Lift a Jumbo Jet

In my previous contribution I outlined my experience as a junior Engineering Officer in the Royal Air Force, after a number of different appointments and having gained a lot of experience in different engineering fields I decided to exercise my option and retire from the Service in July 1988. The area where I least wanted to work was Leicestershire however, that was where we ended up. I had applied to a division of the GEC empire which was based in Kent but by the time I joined it was being re-located to Whetstone on the outskirts of Leicester. The company was being rationalized and re-organized so although I initially joined the Special Projects Division which encompassed mineral processing, postal sorting machines and a wide variety of defence equipment within a short time I moved to a new division titled Defence and Maritime as a Project Manager. The legacy equipment which I had been responsible for was rapidly becoming obsolete so I was actively looking for new projects and for a while worked on Off Shore Oil Equipment including tanker mooring and loading equipment I also seemed to pick up a variety of odd ball projects which had no clear home.

It was in late1989 when I returned from holiday and one of my colleagues, who happened to be a retired Naval Engineering Officer from Nuclear Submarines, came up to me and said he had a project which was right up my street. While I was away the division had been invited to a briefing on a major project for an Aircraft Maintenance Hangar, we had been asked to make a proposal for a Jumbo Jet Lifting System to be installed in the Hangar and he had attended the briefing and was putting together the project approval form for the Director so how much did I think it was worth? Off the top of my head I said £1 million a set! The hangar would have three bays so at a total of £3million it was a project worth some effort.

My colleague was very pleased to hand over the project to me and I was soon in contact with Ove Arun who were the design consultants followed by meetings with British Airways Facilities Group to refine their requirements. Within a few months we had produced a concept design and made a presentation to the Ove Arup and BA project team. We were confirmed as the preferred supplier and this would be confirmed to the prospective civil contractors. It was now that having established good relations with the Project Team payed off as we learnt which civil contractors had been asked to bid and we were able to ensure that our proposal was included in their bids.

Balfour Beatty were selected as the Main Contractor so I then set about establishing ourselves with their project team who at that time were based in Croydon, not the easiest of journeys from Leicester. One of our biggest obstacles was our own Commercial Department who categorically stated that we would be able to bid to civil contact conditions as they were unacceptable to GEC. After much discussion we did accept the terms with some minor changes and once Balfour Beatty had been awarded their contract we got ours and began to work on the detail design.

Our design comprised nine platforms in a set, one platform carried the nose landing gear with an adjacent platform which was also lowered to provide clearance for retraction testing. The main landing gear was carried on four platforms with an additional three platforms providing clearance for retraction tests. The platforms were each supported on four electrically driven screw jacks mounted on a fabricated stool about 2.5M tall. The drive was by means of motor on each stool which drove all four jacks by shafts and

gearboxes. The movement of the platforms could be controlled from a power cabinet mounted on the hangar wall or from a portable control box which could be plugged in adjacent to the nose wheel platform.
The requirement was to provide a set of platforms which would form part of the hangar floor they were required to take the weight of a fully laden Boeing 747-400 just over 350 Tonnes they should be capable of lifting the load 500cm above floor level and lowering 500cm from floor level. When unladen the platforms would be capable of travelling 2m below floor level, this was to provide clearance to carry out retraction test on the aircrafts undercarriage whilst it was jacked up and the maintenance access docking was still in place. The platforms were required to operate either all together in alignment or individually if required.
The platforms had to withstand the edge loading as the aircraft wheels rolled on to them off the hangar floor and this extreme loading defined the design case. The main platforms were a welded fabrication from 50cm deep section with a top plate of 2.5cm plate. The nose wheel platforms were of lighter sections due to the reduced loading. The largest platform was 5m x 6m which presented transport problems.
Our design team soon produced our own specification and we were able to start looking for components. A key part of the system were the jacks 4 on each platform and we soon found a UK based supplier and started discussions with them on our system requirements. The control system would also be a key part of the design with the requirement to control the platform speeds in order to keep them in alignment even though they were carrying different loads. The electric drive motors would have inverter drives which would allow for the different speeds and these would be the cause of some problems later.
Throughout the design process we had kept our customer, Balfour Beatty, in the loop however, the end user British Airways (BA) and also the Consultants, Ove Arup, also wanted an input with their requirements. One point which was later to cause problems was the locking of the platforms; we had chosen screw jacks which had irreversible drives, in that the angle of the screw thread would not allow the load to cause the jack to rotate and self lower, this seemed a sensible choice to keep the drive system simple and all design analysis confirmed it would work. At customer review the user, BA, required that the drive system had a physical brake applied when the platforms were stationary; the solution was a disc brake on the motor drive shaft the brake was applied by a spring pack and released by a solenoid when power was applied to the motor. This appeared to be a simple solution to meet BA requirements but again was going to feature during commissioning of the installation.
By the end of 1990 the design was sealed and manufacture could start, I had already looked at possible steel fabricators in the Cardiff area, in order to reduce transport problems and costs, but a managerial decision at Whetstone was that the as much work as possible must be done in our works. At the time we had a large workforce waiting to start on a number of projects which had been delayed. It had been agreed with BB that we would manufacture all the platforms in one run and then they would be paid for but kept in storage at our site until required for installation. We started production of the platforms and stools and within 6 months we had completed the 350tonnes of steel fabrications.

Balfour Beatty were responsible for the construction of the floor pits into which the platforms would be installed, initial concerns about the anchor bolts for the stools were solved by us producing a template and the anchor bolts being cast into the floor in jackets of polystyrene. Once the floor had set a solvent was used to resolve the polystyrene providing clearance for the bolts to align when the stools were installed and the space subsequently filled with grout.
The platforms were guided by rails bolted to the side walls, again we provided the drawings to BB who included box outs and anchor bolts in their shuttering to cast the pit walls, however this time gravity was not helping and flexibility in the formers resulted in out of position bolts and distorted beds for the guide rails; these problems were solved and eventually we were able to install the rails within the very tight tolerances needed to ensure the platforms would move smoothly throughout the full range of movement.
It was when the platforms were installed and we started testing them that we encountered the major problem; whilst everything ran Ok when we stopped the platform something was causing the inverter drive to fail. At a regular review during the procurement process our buyer revealed that he had come in below the estimated cost by buying the motors from one supplier and the inverter drive from someone else. After much discussion I had insisted that both motors and inverter drive
should be purchased from the same supplier. It was evident that the shut down failure was caused by either the motor or the drive so we called in the supplier to investigate. A recording oscilloscope was connected into the system and a trial start and shut down carried out. A review of the recording revealed that a power spike was generated in the system just after the power was shut off but we could not clearly see where it came from. Eventually we discovered that as the power was shut off the solenoid operated disc brake operated and that the armature moving through the solenoid was generating a back emf which was sufficient to blow the inverter. The problem was easily solved by putting a capacitor across the windings which allowed the emf to dissipate. Had we sourced the motor and inverter from different suppliers we could have spent a long time to determine which components were at fault in our case the responsibility was clearly placed on the one supplier who soon resolved the issue.
It was truly amazing when shortly after the completed hangar was in operation Blue Peter featured it on a program and the operation of the platforms formed a large part of the report, my daughters were very impressed. A couple of years later I arranged to visit the facility to show it to another potential customer and they were very impressed with the design and how it operated. BA were well satisfied with the system, and by being able to carry out retraction tests of the undercarriage whilst the staging was still in place and not having to jack the aircraft again they saved 3 days on a servicing and as at that time a 747 generated an income of £50k per day it was a good investment.
By the way the value of the contract was £3,086,000.00 not far from my initial estimate.
I have attached two pages from the Ove Arup Journal 3/93, which show the layout of the platforms and the first aircraft being towed into position on the platforms. The journal is available on line and covers the whole of the Dragonfly Project.

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