The Teenage “Baby” on Show

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Abstract. It is now fifteen years since the replica of the Manchester University Small-Scale Experimental Machine (“Baby”) was handed over to MOSI, the Museum of Science and Industry in Manchester. This article summarises some of the experience of the exposure of the object to the public from the point of view of the volunteers who maintain and demonstrate it.

Keywords: SSEM, Small-Scale Experimental Machine, “Baby” computer, computer replica, MOSI, Museum of Science and Industry, Manchester computers.

1 The “Baby” Replica

The original Small-Scale Experimental Machine was built in the Electro-Technics department of the University of Manchester by Williams, Kilburn and Tootill in 1947 and 1948 [1]. It was a test-bed for the cathode ray tube storage system which they had been developing since before 1946 [2]. On 21st June 1948 it correctly ran a program to calculate the highest factor of an integer, thereby becoming the earliest stored-program computer to work. The machine was subsequently greatly enlarged and developed so as to become the prototype of the Manchester University Mark I computer in 1949.

In late 1994 the Computer Conservation Society (CCS) instigated construction of a replica of the computer as it existed in June 1948 [3]. The goal was to run that first program again on 21st June 1998 to celebrate 50 years of stored-program computing. The project was sponsored by the computer systems company ICL and the assembly took place in Manchester Computing Centre in the Computer Science building at the University of Manchester. The work was done by a small team of volunteers, most of whom were members of the CCS. The workshop team in ICL’s West Gorton R&D centre manufactured parts, but construction and wiring of sub-assemblies was done by volunteers in their homes. These electronic units and mechanical items were then brought to the university for assembling into the complete system.

The replica was complete and working by February 1998, whereupon it was dismantled and transported to MOSI. Here it was re-assembled and the next few months were devoted to tidying, shaking-out remaining errors and generally preparing for the anniversary celebrations. Highlight of the celebrations was running the first program again by the same men who achieved it 50 years earlier, and then the formal handing-over of the machine into the care of MOSI [4].

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The museum is itself located on an historic site, with numerous large and important buildings dating from the mid-1800s and earlier. These buildings are of intrinsic interest themselves, as well as housing and displaying the museum collections. Focus is on Manchester-oriented inventions and history, so collections cover textile manufacture, steam engines, railways, city infrastructure, the factory system and so on. Very good interactive galleries for children are present, indeed there is a strong learning environment for parties from schools.

One large four-storey building is “The 1830 Warehouse”, the world’s first railway goods warehouse. This is largely intact from Victorian times – brick-built, wooden floors, timber and cast iron pillars, large windows and hydraulic hoists, all still present. In 1998, the top floor was empty but planned to become the “Futures Gallery” to show communications, from writing to railways, and telegraph to television. It was felt that this would be a suitable background to display the “Baby”, and plans were made to move it there.

Fig. 1. The 1830 Warehouse (Image ©MOSI)

2 A Luggable Computer

The original machine was experimental and most interconnecting wires between units were made to screw terminals. The replica echoes this construction so to move it conveniently it is divided into nine separate racks of equipment by disconnecting about 200 carefully labelled wires. A team of four men can then carry each rack onto appropriate transport. This requires care because the electronic components are not protected in any way and so are vulnerable to accidental damage.

2.1 Move 1 – University to Top Floor of 1830 Warehouse

The racks of the machine were moved the few miles from the university to the 1830 Warehouse on Tuesday 24th February 1998. Two days later the machine had been connected up together again and worked after fixing a few small faults. This quick return to working order was a great tribute to the care with which the ICL operatives transported the machine.

As already mentioned, the installation was handed over to MOSI a few months later, and there it could be shown to the public in a spacious and authentic-looking setting. There was no "passing trade" – museum visitors had to find out from signage and enquiry where the "Baby" was, and then make the effort to ascend to the top floor to find it. Nevertheless there was a steady stream of visitors and probably very few days with no visitors. There were sufficient volunteers available to respond to visitors on Tuesdays from 10:00 to 16:00 with a pattern of scheduled demonstrations at 12:00 and 14:00. On other days a 'visitor present' detector triggered a voice commentary with synchronised spotlights to enliven the exhibit and educate the visitor.

Fig. 2. "Futures Gallery" – Top Floor of 1830 Warehouse – 1998 to 2005 (Image ©MOSI)

Computers are notoriously boring to look at unless there is something moving or animated. For "Baby" the interesting thing to watch is the monitor cathode ray tube, 6 inches diameter, showing the pattern of 0s and 1s in the store, and where the results of computations are displayed. For safety, the public is kept 2 meters away from the machine by a barrier and the monitor screen is too distant to see clearly. We therefore embedded two slave monitor screens in protected housings within the barrier for close inspection by visitors. However we eventually found that we could not maintain adequate brightness from these tubes at affordable cost, and the technique was later abandoned and a bright oscilloscope placed near the computer as a substitute

The replica remained in place for almost seven years and was demonstrated to visitors once a week. The museum plans now called for re-allocation of space on the Top Floor. So in April 2005 the machine was dismantled once again to move to a new location.

2.2 Move 2 – Top Floor to Second Floor of 1830 Warehouse

Preparations, transporting the machine and re-assembly took a few days by museum staff. Connecting and re-commissioning took a couple of weeks' part time work by volunteers, whereupon the pattern of displaying and demonstrating the "Baby" re-started. It was now somewhat easier for visitors to find the machine, and visitor numbers were increasing. A number of VIPs including the Prime Minister at the time were escorted up to see the machine in operation as it was becoming recognised as an important representative of Manchester's scientific and industrial history. The site was somewhat gloomy, although quite in keeping with the original university laboratory. However, after two years, in mid-2007, yet more upheaval was anticipated as the whole area on the second floor was earmarked for an important new gallery sponsored by British Telecom called "Connected Earth". We were on the move again. By this time MOSI had much more ambitious plans for "Baby".

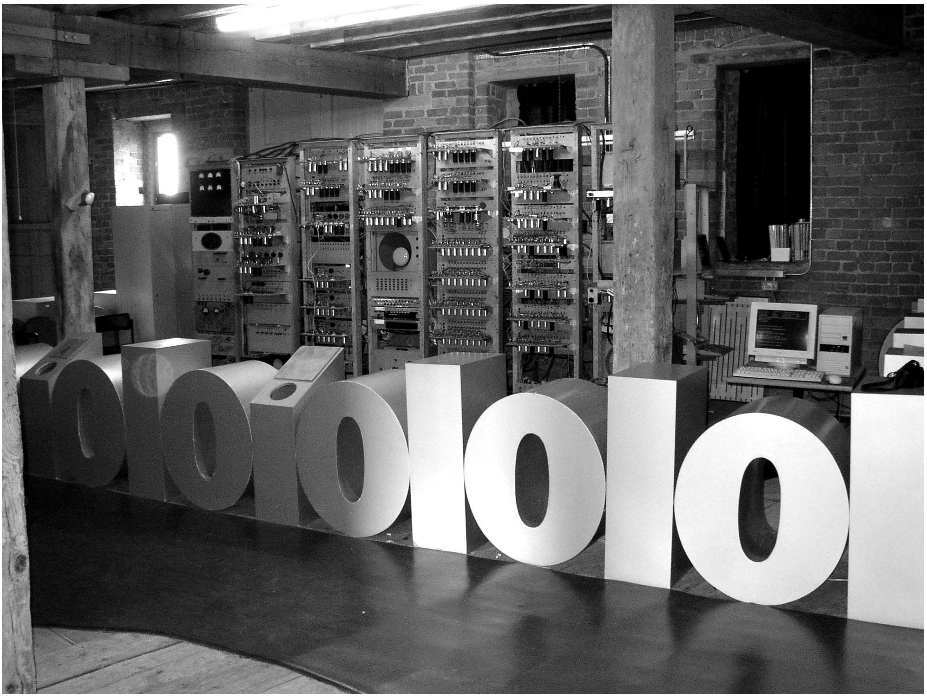

Fig. 3. Second floor of the 1830 Warehouse – 2005 to 2007

2.3 Move 3 – To Ground Floor of Main Building

The Grand Plan was that the Main Building, also known as the Great Western Warehouse, another historic building on the site, was to be transformed internally. On the ground floor is the primary visitor entrance area, with substantial galleries and services on the three floors above. A major ground-to-roof reconstruction would provide a very large visitor orientation area on the ground floor and prestige galleries and conference facilities on the floors above. “Baby” would be part of this scheme. This was the plan but it was some way off for implementation, and meanwhile “Baby” would be on display on the ground floor, not far from where visitors currently arrived, and right on the route visitors took to other parts of the museum. In the public eye indeed!

Once again, the machine was un-wired and disassembled, to vacate the space needed by Connected Earth. It took some time to prepare the new site in the Main Building which was a little smaller than we were used to, and care had to be taken to ensure the safety of visitors. So the machine was in limbo for a couple of months before the volunteer team could get access to re-assemble and re-wire. Once power was available on-site, it took a day to confirm the computer was in good order and ready to display and demonstrate to the public.

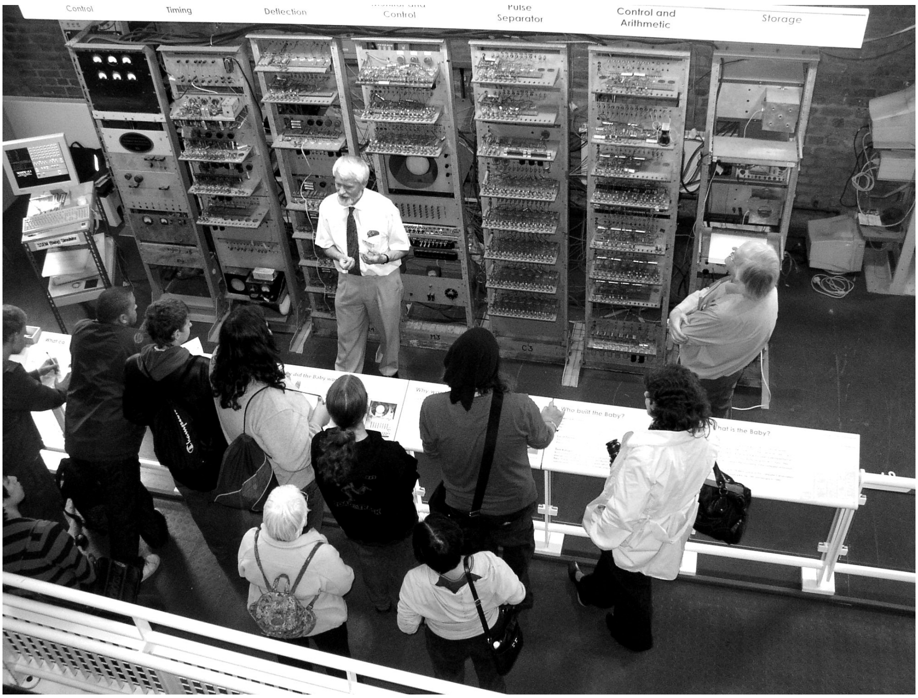

Fig. 4. Ground floor of Main Building – 2007 to 2009

The new location meant that there were many more visitors looking at "Baby" even on non-demonstration days. Audio-visual aids in the barrier surrounding the machine helped tell people what they were looking at. A recruiting drive had yielded several extra volunteers able to talk about the machine and the history of the original, so there was non-stop activity all day on Tuesdays, and occasional demonstrations on other days and weekends, for example at school holiday times. Evening demonstrations for conference delegates were also very popular, sometimes accompanied by more formal lectures.

But our months in that location were numbered, as planned from the beginning. After just two years, the system had to be moved into storage so that the huge refurbishment task in the building could start. In November 2009 everything was transported to a secluded storage area further along and higher up in the building, where nominally no construction work was to take place. How little we knew!

2.4 Move 4 – Ground Floor to Storage Area of Main Building

The expectation was that the "Baby" would be safe in storage together with the large quantity of spare valves (vacuum tubes) and other components and associated test equipment and documents. There was insufficient availability of power to be able to operate the whole machine for testing purposes while in storage, though there was the prospect of applying power to separate parts of the system.

Fig. 5. The spacious Revolution Manchester Gallery – "Baby" in far corner (Image ©MOSI)

At some stage in early 2010, the building contractors broke through the partition barrier and stored quantities of drywall gypsum plaster-board in the area. This was not discovered for several weeks, when the volunteers were astounded to find that the place had also been used as a workshop for cutting-up the drywall, and everything was coated in a thick layer of powder. Not the most appropriate way to look after a museum object! When the builders had been ousted, the team spent several weeks during June and July with brushes and vacuum cleaner attempting to restore the situation. Repairs were made to the chassis which had been damaged and where possible a limited amount of testing carried out.

Meanwhile a splendid new spacious visitor orientation area, the ‘Revolution Manchester Gallery’ was being completed, and preparations made there for a site for “Baby”, to be highlighted as an ‘Icon of Manchester Science’. Once again the barrier separating the public from the machine would be exploited, with embedded iPads and other interactive material for use by visitors. In mid-November 2010 the racks were yet again carried to the new site, placed in position and the machine covered in dust sheets pending completion of the gallery. The machine had been out of the public’s gaze for a little over a year, had endured two moves and there was evident physical damage to many of the fragile valves.

2.5 Move 5 – Storage Area to Revolution Manchester Gallery

Fig. 6. - Visitors interested in “An Icon of Manchester Science”

A week before Christmas 2010 a power feed was available on the new site and the work of re-commissioning could begin. Visual checks showed that at least 50 of the little glass diodes had bent pins or cracks in the glass, not always fatal, but a cause for concern. This was due to suffering in the “builders’ workshop” and insufficient recognition of the vulnerabilities by staff moving the machine. After weeding out defective diodes, and locating and repairing various broken or disconnected wires, the machine was running programs again in January 2011. The volunteers achieved this success in only eight work days, despite the intervening holiday, but assisted by the piecemeal testing that had been possible after cleaning while in storage.

In the past two years on the new site, the “Baby” has settled into a pattern of more regular attendance by volunteers able to talk about the object to the public, so that usually three days per week are staffed. The size of the volunteer team has doubled, taking a load off those volunteers who are able to repair the machine. The machine is by no means very reliable – areas of concern are residual problems due to past damage to valves, severe problems due to ageing of resistors, especially in the sensitive analogue arithmetic units, and problems maintaining the CRT stores. In many cases the machine can be kept working by artifice and backup facilities, but in any case visitors seem to enjoy watching volunteer engineers, equipped with oscilloscope and test meter, attempting to fix faults.

3 Some Reliability Data during 15 Years on Show

The volunteer team maintains a maintenance log book to record faults, repairs and notes to communicate with other volunteers. Discipline in filling-in the log is usually quite good, but inevitably varies with individual consciences and the degree of mental concentration in different circumstances. Frequently, an adjustment of a control for example will not be recorded. Similarly, in the heat of the moment, replacement of a valve might not get recorded. Nevertheless, assuming omissions are random, and inclusions are of faults which take most time to clear, some sort of comparison of faults over time can be seen in Table 1 below. The figures belie the amount of time spent just trying to figure-out that a fault is present and what is causing it. The data includes re-commissioning after a move as well as in normal demonstrations, hence the unexpectedly high number of connection faults.

Apart from the large number of valve faults in 2010 due to physical damage, it is surprising how few faults of this type have appeared over the years. The original machine was said to have required several valve replacements per week. The difference may be attributed to a couple of reasons – a) the replica is only switched on for a few hours per week and b) the valves we have used were new but old stock, probably made in the 1950s when manufacturers were forced to pay attention to reliability. The pioneers had to make do with items made in the frenzy of wartime.

Table 1. Categorised definite faults

Year	Faulty valve or CRT	Connection	Other small component	Power system	Other	TOTAL
1998	1	2	3			**6**
1999	2	3	2	4	3	**14**
2000	2	3	4	2	1	**12**
2001	1			2		**3**
2002	1	1	1	4		**7**
2003	6	2	2	1	3	**14**
2004	1	1	2	1	1	**6**
2005	2	6	3	2	3	**16**
2006	1	3	3			**7**
2007	2	8			4	**14**
2008	5	2			2	**9**
2009	1		2	1	1	**5**
2010	19	2				**21**
2011	5	4	5		2	**16**
2012	3	1	3	2		**9**
2013	6		1			**7**

4 The Volunteer Team

For the first year of operation, the team of volunteers who had built the replica performed demonstrations and talked to the public. As the years passed so these individuals dropped-out and fresh enthusiasts joined-in, and inevitably there was change in expertise in repair skills. On the other hand newer volunteers tended to be more self-selecting to be good at interacting with visitors. Recently the classification of volunteers has been systematised to provide a “volunteer career path” and a contribution to improving Health and Safety issues [5]. Level 1 people are explainers but are not qualified to operate or even to switch-on the “Baby”. Level 2 embraces Level 1 and additionally the volunteer may operate the machine to run defined programs. Level 3 qualifies to run test programs and make diagnoses, and perform fallback procedures to maximise demonstrability of the machine. Finally, Level 4 volunteers are those able to do all the previous tasks and carry out detailed diagnosis and repair of the machine. This grading scheme is in line with similar schemes being set up at the London Science Museum and at The National Museum of Computing.

The enthusiasm, skill and dedication of the team of volunteers are major factors contributing to the success of the “Baby” as a museum object. They are helped by the Museum’s policy of encouraging and supporting volunteers. There is a “Friends” organisation with accommodation on site, which has been in existence for decades, and which formally represents volunteers’ views. From time to time MOSI will provide a script for volunteers to use to succinctly tell the story within a visitor’s span of attention. This is a good basis, but inevitably the explainer will embellish with his own thoughts, depending on the degree of knowledge or interest shown by the visitor. As one of the key volunteers tellingly said, *I find the following always gets a positive reaction and immediate understanding by the public of where we have come from. We hold up a Cathode Ray Tube and say, “This was what a flash drive looked like in 1948, long before we invented USB, and it holds less than a millionth of a gigabyte!”*

This dependence on volunteers to bring otherwise boring hardware to life is reinforced by the following statement [6] by John Beckerson, Senior Curator at MOSI. The author is grateful to him for permission to pass on his comments.

‘That’s cool!’ a teenage visitor remarked upon encountering parts of Baby when it was last moved across site by a sweating team of curators and volunteers.

You’d think that 1940s technology would be far from ‘cool’. Yet today’s teenagers and digital creatives find the Baby a fascinating example of early electronics because their lives are so deeply reliant upon electronic devices descended from its principles. The Baby has more appeal now than it had 20 years ago; because as we move to an increasingly digital world, public curiosity about the origins of that world is thriving. People far beyond the walls of academia have become familiar with illustrious names such as Turing and the Manchester Baby has put the names of Williams, Kilburn and Tootill on that list.

For the Museum, the Baby has been one of our great success stories. It is a compelling visitor attraction. When the Museum produced its newest gallery, Revolution Manchester, it was no surprise that the Baby found pride of place as one of the iconic objects in our collection. Not only does it stand as a signpost to the digital future, it also helps today’s citizens understand a part of our scientific and industrial past which is just as important as the glorious steam engines which are so popular in the adjacent Power Hall.

Part of the reason the Baby is so popular is the thousands of hours of volunteer time which go into maintaining and explaining it. Thanks to the storytelling expertise of the volunteers, what might otherwise be a curious but also mysterious and incomprehensible object becomes a living tale about discovery, the men who made it happen, and the impact of their research. The huge value that our volunteers bring enables them to speak at different levels. They interpret the Baby in different ways to suit each visitor. One person might simply require a brief summary: whilst another could be an engineer desiring deep technical detail. No fixed exhibition could ever provide this level of flexibility. It is the winning combination of the machine and the men and women who run it - and tell its story every time they come on duty - that makes the Baby one of MOSI’s best-loved exhibits.

5 Conclusions

During the fifteen years of its display in the museum, the “Baby” has endured a surprising amount of movement and disruption. This is uncommon for a large object which is complex, operational and requires dismantling and re-assembly every time it moves. Nevertheless, it is always repairable and can be brought back to life by the enthusiastic volunteers. That enthusiasm is manifest when they explain the history and functionality of the machine to visitors. In its current location as an Icon of Manchester Science, it is more popular than ever with visitors, providing an unusual

and spectacular attraction. The author is grateful to curatorial staff at MOSI for help in preparation of this paper, and especially to the volunteer team who are proud to feel that is "their baby".

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