From arms, planes and racing cars to ventilators: industrial conversion during the COVID-19 crisis

Dr Stuart Parkinson, SGR, assesses the UK's crash industrial programme to scale up production of medical ventilators during the pandemic – and what lessons can be learned for conversion away from fossil fuels and arms.

As cases of COVID-19 accelerated in the UK in early March 2020, one of the problems that analysts in the National Health Service (NHS) realised was that there could quickly be a massive shortage of mechanical ventilators. Ventilators are machines that assist or replace a patient's breathing by moving pressurised air in and out of the lungs, and they provide life-saving care for many patients with COVID-19 and other major respiratory illnesses. Mechanical ventilators are the type used for the most severe cases. The NHS analysts estimated that, in a 'reasonable worst case' scenario, up to 90,000 beds with ventilators would be needed to care for COVID-19 patients – but only about 7,400 mechanical ventilators could be accessed.[1] The government responded both by trying to order as many units as it could from existing medical suppliers (both in the UK and internationally) and by calling on UK industry to scale up the domestic production of ventilators. In this article, we'll focus on the second of these as it offers an important case study of rapid industrial conversion to meet a social goal.

UK ventilator consortia

UK companies quickly formed numerous consortia to respond to the call – and the main ones are summarised in Tables 1 and 2, according to whether or not they went on to supply the NHS. The approaches taken by these collaborations fell into two categories:

1. Scaling up production of existing ventilator designs; and
2. Designing and manufacturing new devices.

In general, the first approach was more successful given the very limited timescale, and consortia pursuing this option were the ones which eventually went on to supply the NHS.

Table 1. New/ expanded consortia which supplied the NHS with mechanical ventilators[2]

Ventilator models	Companies involved	Numbers supplied
Prima ESO2	Ventilator Challenge UK/ Penlon consortium Key organisations: High Value Manufacturing Catapult (govt body/ lead), Penlon, Ford, Airbus, McLaren, Siemens, STI No. of companies involved: 31 No. of supporters/ suppliers: 30	11,700
Parapac 300/ 310	Ventilator Challenge UK/ Smiths consortium Key organisations: Smiths Medical, Rolls-Royce, GKN Aerospace Total numbers involved: as above	1,500
Nippy 4+/ Vivo 65	Breas Medical	2,000

One surprising element is that many of the companies involved did not have a track record in the design or production of medical devices. Significantly, they included arms corporations – such as Babcock and BAE Systems; automotive companies – both those involved in mass production vehicles, such as Ford and BMW, and motor racing teams, such as McLaren; and

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aviation giants – such as Airbus. Table 3 summarises the main sectors from which these companies were drawn.

Table 2. New/ expanded ventilator consortia which did not supply the NHS[3]

Ventilator models	Companies involved
Zephyr Plus	Draeger; Babcock
Gemini	OES Medical; BMW
3CPAP (SOG)	Vobster Marine Systems
Piran Vent	Swagelok
VelociVent	Cambridge Consultants; MetLase
Mosquito	Sagentia
CoVent	TTP; Dyson
AirCare	Intersurgical; BAE Systems
EVA	TEAM Consulting; Cogent Technology
Helix	Diamedica; Plexus
OxVent	Oxford University; Kings College London; Smith & Nephew
InVicto	JFD
BlueSky	Darwood IP/ Formula 1 teams; Olympus Medical

Table 3. Sectors represented by companies in UK ventilator consortia

Sector	No of companies: Ventilator Challenge UK	No of companies: Other consortia
Medical	6	13
Automotive:		
Passenger cars	1	2
Motor racing	8	4
Military technology	7	2
Aviation (civilian)	3	0
Academia/ public sector	1	3
General engineering/ other	11	6

Data is drawn from Tables 1 and 2 and references therein. Note that some companies are categorised in more than one sector.

CASE STUDY: THE VENTILATOR CHALLENGE UK / PENLON CONSORTIUM

In order to understand the level of success of the ventilators programme, let's examine the Ventilator Challenge UK/ Penlon consortium in more detail.[4] This group was the one which ended up supplying the largest proportion of new mechanical ventilators to the NHS (see Table 1). It opted to modify the design of an existing anaesthesia machine for use in treating COVID-19 patients. The existing model was being manufactured by a small Oxford-based medical device company called Penlon. To appreciate the complexity of this device, bear in mind that its construction consists of 700 individual parts, sourced from 88 suppliers. As one senior engineer involved in the project put it, each ventilator is "not quite as complex as a car". Furthermore, the device had to pass through rigorous medical and engineering certification processes before it could be made available to the NHS.

Once approval had been granted, the consortium rapidly ramped-up production of the device. The speed with which it did this was impressive. The first unit was produced just four weeks after the government issued its call for help – in mid-April – while only 12 weeks after that, about 11,700 units had been completed. Production was being doubled every few days, and the consortium went on to achieve a production volume that was 200 times the rate of the original model! It was able to achieve this transformation by converting four manufacturing sites, each one in a different company in a different sector and in a different part of the country:

- Ford in Dagenham, Essex;
- Airbus in Broughton, North Wales;
- McLaren in Woking, Surrey; and
- STI in Hook, Hampshire.

Approximately 1,500 technical staff were involved, and training was carried out at a distance using 'mixed reality' headsets. These were modified from virtual reality devices so that new templates and designs for the manufacture and assembly of components could be projected in front of the technicians' eyes while they worked. An extra complication was that, of course, all this activity had to take place under 'lockdown' conditions – so workers also had to adapt to using new personal protection equipment, social distancing protocols, and video conferencing technology.

An engineering success but medically irrelevant?

In engineering terms, the ventilator programme was a major success for British industry – but how did it fare in achieving medical goals?

Let's first consider where the programme succeeded and the reasons for this. It achieved – in a remarkably short time – a huge scaling up in the production of complex, potentially life-saving medical devices. Over 15,000 mechanical ventilators were produced to strict medical standards in just a few months by converted or expanded manufacturing facilities.[5] Senior engineering staff involved in ventilator programmes gave a number of reasons for this success, including:[6]

- Shared social goal – with a specific and urgent health aim;
- Existing high quality manufacturing sites and staff – coupled with high quality control standards;
- Willingness to innovate rapidly – described as a 'will-do culture'; and
- Collaborative working practices – including close cooperation between regulators, businesses, and trade unions; a flat management structure; data sharing between all businesses and government; and a simple relationship with the customer, i.e. government.

However, in medical terms, the success of the programme is open to question. Firstly, the existing NHS availability of ventilator-beds was nearly twice the peak demand from patients in April 2020 – and, anyway, only 200 new ventilators had been manufactured by then.[7] The January 2021 peak in demand from COVID-19 patients was about 25% higher than the April peak[8] – not enough either to require the extra ventilators. Indeed, media reports at the time highlighted that there were local shortages in the number of *beds* in Intensive Care Units to treat COVID-19 patients – a rather different problem.[9]

A further consideration is that, in parallel with the industrial conversion programme, the NHS was able to buy an additional 11,000 mechanical ventilators through the existing global supply chain.[10] That alone more than doubled the NHS stock of ventilators, rendering the new UK manufactured devices superfluous.

However, one area where a UK industrial programme did yield significant medical benefits was in the production of new 'CPAP' machines. These simpler, 'non-invasive' ventilators are also used for COVID-19 patients, depending on their specific symptoms. In parallel with the industrial programmes listed in Tables 1 and 2, University College London partnered with Mercedes Formula 1 engineers and G-TEM to manufacture 10,000 of these devices in a plant in Northamptonshire.[11] From the information available, these seem to have been widely used by NHS hospitals.

Of course, the government could not have been sure in advance that lockdown and other measures would have been sufficiently successful to negate the need for the ventilator programme – especially given the initial reasonable worse case scenarios – so there was no choice on the need to pursue it at the time – but this demonstrates the importance of better pandemic emergency planning, following the examples seen in some other countries.

One other aspect is worth noting here. Having rapidly scaled up production, the Ventilator Challenge UK consortia were completely shut down in July once the government decided the NHS had enough new equipment. All the participating factories were then converted back to their original manufacturing processes – including military technologies, racing cars, and airliners. Hence the opportunity to establish a more permanent conversion to socially-useful production was missed.

Lessons for the climate emergency and arms conversion

There are clearly important lessons from this programme for other efforts to convert production. In particular, the argument that it is too difficult for industries to rapidly move away from reliance on fossil fuels or arms contracts has been left in tatters, as it was exactly these companies which were most heavily involved in the ventilator programme. Industrial success was achieved through a combination of: political will focused on clear social goals; rapid industrial innovation; partnership working across businesses, government and trade unions; and adequate funding for reskilling and retooling. These could and should be the focus of the industrial contribution to tackling the climate crisis and curbing international arms races.

One final lesson has also been strongly exemplified by the ventilator programme: the importance of early action. A great deal of effort was expended by the UK industrial consortia, but most probably had no medical benefit. Better emergency planning for pandemics had been recommended by numerous UK studies in recent years, but this advice had not been actioned. This echoes the slow response in implementing lockdown measures as cases started to rise. If we don't heed similar advance warnings for the climate crisis or nuclear arms control, the consequences will be even worse.

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This article is updated and expanded from a presentation given at SGR's 'Transition Now' conference.

References

1 NAO. (2020). Investigation into how government increased the number of ventilators available to the NHS in response to COVID-19. National Audit Office. September. https://www.nao.org.uk/report/increasing-ventilator-capacity-in-response-to-covid-19/

2 Ventilator Challenge UK. (2020). Companies involved. https://www.ventilatorchallengeuk.com/ ; NAO (2020) – as note 1. NB Figures are rounded to the nearest hundred.

3 NAO. (2020) – as note 1

4 All the material in this section is sourced from: Ventilator Challenge UK. (2020). The consortium. https://www.ventilatorchallengeuk.com/ ; BSI. (2020). Building on the ventilator challenge. Webinar; October. https://www.bsigroup.com/en-GB/our-services/events/webinars/2020/building-on-the-ventilator-challenge/

5 NAO. (2020) – as note 1.

6 BSI. (2020) – as note 4; Wainwright H (2020). Swords into ploughshares; planes into ventilator parts. Red Pepper. https://www.redpepper.org.uk/swords-into-ploughshares/

7 In April 2020, the peak demand for ventilator-beds was approximately 3,900 – 73% of them for COVID-19 patients – whereas over 6,800 ventilator-beds were available (NAO. (2020). note 1). Later data put the peak demand slightly higher (HM Government. (2021). Coronavirus (COVID-19) in the UK: Data: Patients in mechanical ventilation beds. https://coronavirus.data.gov.uk/details/healthcare ; accessed 9/2/21).

8 Nearly 4,100 (HM Government. (2021). note 7)

9 BBC News online. (2021). 'Record number' of Covid intensive care patients transferred. January. https://www.bbc.co.uk/news/health-55766414

10 NAO. (2020) – as note 1.

11 UCL. (2020). Breathing aids developed by UCL, UCLH and Formula One delivered to nearly 50 NHS hospitals. May. https://www.ucl.ac.uk/news/breathing-aids