

The 2011 off the Pacific Coast of Tohoku Earthquake Restoration Could Be the Dawn of a New Phase at Soma Aero-Engine Works: On-site Capabilities and Innovative Manufacturing Technology Are Key to a Fast Recovery

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The Soma Site of Aero-Engine & Space Operations (Soma Works 1&2, IHI Castings Co., Ltd., and IHI Jet Service Co., Ltd.) is located in the northern part of Soma City, Fukushima Prefecture. During the 2011 off the Pacific Coast of Tohoku Earthquake, a violent tremor registering six on the Japanese seismic scale occurred and the site suffered the most serious damage among all the sites of the IHI Group. Nevertheless, as a result of the joint restoration efforts of the IHI Group companies, we were able to declare full restoration of the Soma Site in the middle of May 2011. This paper reports on the extent of damage, the process toward restoration, the lessons learned from the earthquake, and our vision for recovery efforts going forward.

Soma Office — A global production site for jet engine parts —

Soma Works 1 was established in 1998 as the fourth production site of Aero-Engine & Space Operations and since its inception has integrated production from castings to dedicated machining for turbine airfoils. In 2006, Soma Works 2 was opened by transferring and expanding upon the full capabilities of Tanashi Works in order to meet increasing demand and to introduce innovation in production. Soma Works 2 is capable of manufacturing a wide variety of engine parts. Both works play key roles in jet engine manufacturing for Japan's Self Defense Force. They also support increasing demand and next generation engine development for the commercial sector. For example, these works manufactured some of the engine parts for the Boeing 787 that flew to Japan recently.

Making the most of the local culture and climate

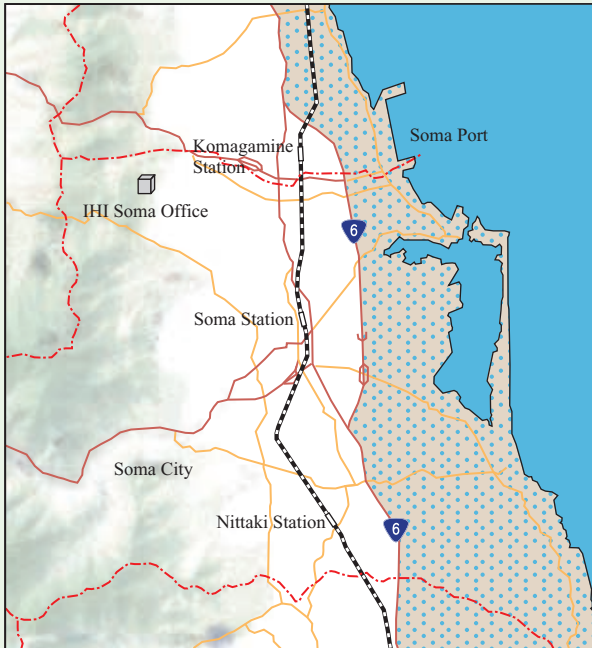
Soma was selected as the aero-engine production site because the area has a good climate for manufacturing operations; there is little damage from typhoons and little possibility of snow accumulating in winter. Even more important, the location has rich human resources. The area has excellent educational facilities, including industrial high schools and technical colleges, and consequently many skilled human resources are available. The frugal and


diligent descendants of those who survived and overcame the many difficulties of the Soma Domain (an administrative division in Japan during the Edo period) have built a rich culture. After considering the geographical features and the possible occurrence of a Miyagi Offshore Earthquake, the works were built on solid ground and emergency earthquake drills were being periodically conducted. Then came the off the Pacific Coast of Tohoku Earthquake.

Our initial response saved lives

The Soma Works are located 7 km northwest of the center of Soma City and 10 km landward from the coast. The giant tsunami caused by the earthquake reached the National Route 6 bypass approx. 5 km away from the coast, but it did not reach the Soma Works site.

However, the tremor was so strong it registered six on the Japanese seismic scale, actually causing some damage to all the infrastructure, including buildings as well as gas, electricity, water, and sewage systems. Offices and automated warehouses also suffered from collapses, falling objects, and other kinds of damage. Miraculously, no one at our site was hurt. We believe this is because the appropriate initial actions were taken as a result of the emergency drills. Unfortunately, later investigations revealed that some employees lost family members, lost their houses to the tsunami, and/or were forced to evacuate because of the nuclear power plant accidents.



Location of the Soma Site and the area affected by the tsunami : 



The ceiling collapsed in this connecting corridor



Warehouse racks (tools and fixtures have fallen)

Confirming the safety of our employees and securing living and information infrastructure

Designating the first week after the earthquake as a period for safety confirmation and establishing secure living environments, we devoted ourselves to confirming the safety of our employees, implementing countermeasures against the possibility of further accidents at the nuclear power plants, and securing relief items as well as means of transportation. We also inspected and restored essential utilities and delivered relief items we received from all over Japan to the local government.

In many areas, the essential utilities had been shut off when the earthquake hit. In particular, the shut-off of the communications infrastructure caused us significant trouble. For example, IHI has a system in which the e-mail addresses of employees' mobile phones are registered to allow for confirmation of their safety in cases of emergency. However, such registration had been voluntary and many employees had not registered their e-mail addresses. The lesson learned is that we need to ensure that all employees register going forward.

Another problem was the unavailability of the network, which inhibited the creation of a restoration plan as well as normal business functions. Soon after the disaster, about 20 employees went to the Akishima Office and worked to support Soma operations. Until network access was restored in early April, the workers at the Soma Site gathered together in a large room at the task force headquarters and kept in quick, close communication with each other. Communication was accomplished in the traditional manner of felt pen and paper, not electronically.

Difficulties in recovering the sub-transformer blocks (cubicles)

The largest obstacle preventing continued operation was the damage to the transformer blocks. Soma Works receive ultra high voltage power (66 000 V) from the Tohoku Electric Power Co., Inc. and transform such voltage with a total of 17 sub-transformer blocks installed in the individual buildings of the works. Seven of these blocks suffered fatal damage, rendering it impossible to operate the machines on the lines in the buildings in which they were installed.

The earthquake drew attention internationally and many of our overseas partners kindly offered to lend us their generators and turbines. Our investigation showed us that we needed to install temporary transformer blocks and lay temporary cables to resume operation quickly. We had never realized the importance of the infrastructure that we had taken for granted until the earthquake. With tremendous support from our business partners, we were able to quickly make progress in this installation work.

All of the damaged transformer blocks had been installed on the second floor of various buildings and thus subject to strong tremors. Whether the equipment was installed on the first or second floor was the difference between life

and death. This is a simple but important lesson we learned from the disaster.

The Soma Works manufacture aircraft engine parts for the Ministry of Defense, and work together with General Electrics, Rolls-Royce, and IAE for the customers such as Boeing and Airbus S.A.S.. Though there was nothing we could do to avoid suspending production as a result of the natural disaster, we wanted to restart operation as soon as possible to send a message to our customers worldwide that our business would continue. After careful coordination with our customers, we drafted a recovery plan and restarted operation on March 29 on the lines in the No. 4 building, which had usable transformer blocks. This building was built in 2008 to manufacture new engine parts for the Boeing 787.

Restart of operation with the help of on-site foremen, team leaders, etc.

This speedy restoration can be attributed to the fact that there was no severe damage to the transformer blocks and machine tools in the No. 4 building as well as the talents of our on-site employees. If machine tools that are used for manufacturing precision parts are displaced by an earthquake or any other reason, diagnosis, adjustment, and leveling must be performed to restore such machines to their original levels of precision. After the earthquake, we had some machines repaired by their manufacturers, but most of the machines were diagnosed, adjusted, and leveled on-site by our foremen and team leaders during the continuing aftershocks. Our employees are one of our

greatest strengths.

We have been implementing improvement activities through the IHI Production System (IPS). We frequently change the layout of machines by relocating them ourselves to flexibly meet changes in demand and continue to improve productivity. We repeat a cycle in which we reduce the size of our machine tools as much as possible, review bottleneck jobs and processes, and apply our unique, innovative manufacturing technologies. Our on-site capabilities for devising smaller machines, making improvements, and getting things done enabled this early restoration.

Declaration of restart of full-scale operation in the middle of May

Before restarting full-scale operation, there were still several hurdles to cross over. Among them was the restoration of the surface treatment process, in which acid, alkali, and other substances had been spilled and liquids had leaked from tanks that were broken by the tremors. The acid solution bank stopped spillage as it was designed to do and thereby prevented environmental damage from occurring. Nevertheless, the possibility remained that harmful substances might be generated by the reaction of solutions inside the building, so we were not permitted entry until after specialists had completed their investigation and collection of the waste fluids.

Some materials, tools, and fixtures in the automated warehouses fell and were damaged. A crane was rendered inoperable, but fortunately it was an IHI product and IHI



Acid solution bank in the surface treatment workshop



Restoration activity



State of the surface treatment tank



Adjustment of machinery



Ceiling light (top: after falling; bottom: after restoration)



Group picture at the restored works

Logitec Co., Ltd. did everything they could to put it back into operation.

Overcoming the above-mentioned difficulties one by one, we gradually expanded operation from the beginning of April. We finished installing all temporary transformer blocks on April 18 and declared a restart of full-scale operation on May 13. All temporary transformer blocks were replaced by permanent transformer blocks during the summer vacation.

Higher-paced production to meet greater demand than last year

In the aftermath of the earthquake, the most important thing was to explain the situation to our customers and ask permission for postponements as well as to achieve our recovery plan. In addition, demand increased in 2011. In concrete terms, we manufactured 590 000 turbine airfoils in fiscal 2010 but we received orders for 790 000 in fiscal 2011. In response, we have asked our partners to meet part of this demand and increased hours of operation, including adding weekends. The critical point is that we will not be able to meet our customers' demands if we work in the same way as we did last year. Instead, we must take this opportunity to evolve further.

Shifting the power consumption peak to adjust for the power shortage

After installing the temporary sub-transformer blocks, power capacity was approximately 70%; in other words, there was a power shortage of 30%. Under such

circumstances, we asked ourselves: how could we continue to operate on the same level as before?

To resolve this issue, we investigated the power consumption of our machines and decided to reschedule the operations of the machines. We found that of the machines at the Soma Site, the heat treatment equipment consumes the greatest amount of electricity, particularly when the furnace temperature is increased to approximately 1 000°C. Conventionally, we had operated several furnaces as necessary without any limitations, but we decided to operate the furnaces in different time blocks. Going forward, we are considering deployment of a flexible smart system that allows the sub-transformer blocks to support each other in case of failure as well as generators and batteries. We will also introduce inverter-controlled and LED lighting, further reduce the size of our machines, and promote energy saving to increase our competitiveness.

How to deal with Japan risk

The earthquake exposed "Japan risk." Concentrating manufacturing facilities in a small number of places improves efficiency and we have been seeking the most economical solutions. However, we must also consider the risks of supply chains that are too concentrated and consider dual-sourcing in case of emergency. Ideally, it would be possible to mobilize the flow line and cellular manufacturing such that in case of emergency the machines can be transported to a safer place for production. To this end, we hope to further improve our technologies, for example, by reducing the size of and standardizing machines.

The earthquake forced us to pay attention to our supply chains and also to recognize the importance of developing skills and on-site capabilities — in other words, fostering human resources.

Not just restoration, but advancement toward a new phase

The early restoration could not have been achieved without the collective strength of IHI and the enthusiasm of the many people who support the Soma Site. We sincerely

appreciate headquarters and our group companies as well as the local government and community for their direct support. We would also like to thank our partners for the support they provided for equipment and construction through our various networks.

Looking back on this period, we realize that a “full restoration” is not our goal. We have come this far with only 70% of power restored. We should use the remaining 30% of power to advance toward a new phase by applying the lessons we have learned. We have confirmed that we still have room to grow and this is a valuable lesson learned

from the earthquake.

We at Soma Site will continue to strive, applying the valuable lessons we have learned as we work toward advancing our works to move one step ahead.

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