FNAL/UCSB Gantry Operation/Maintenance

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The two gantry systems at FNAL and UCSB have been in operation for 3.5 and 2.5 years respectively. There have been close to 700 modules built on these 2 gantries and probably close to the same number of dry runs[1]. Through this initial period of system development and module production, the gantry has been quite reliable. It has withstood the abuse that is inherent in the development of new tooling and software without any major problems.

Neither gantry has had any problems with the drive motors, stages, encoders and associated power supplies that make up the core of the Aerotech system. The UCSB system did lose its computer controller card. This was fixed quickly (within a week) by Aerotech. UCSB also lost the power supply in its Brussel's I/O box shortly after it was initially set-up. This was easily replaced with a temporary power supply until a replacement came from Brussels. The glue boxes, solenoids valve systems, and pattern recognition (PR) systems have worked reliably once we had solved a number of initial setup problems. The current pool of spare parts for US gantry centers is tabulated below.

Major Gantry Component Spares	At FNAL	At UCSB
Brusell's I/O Box	X	
Glue Box	X	
Catania Solenoid Plate	X	
PR camera system	X	
1 of each type of Gantry Servo Amp (3)	X	
Aerotech Gantry Controller Card		X
Aerotech Gantry Extension Card		X
Back-up Gantry Computer	X	X
Gantry Z Axis Stage and Motor		On order
Gantry U Motor	On order	

We are ordering one Z axis stage and motor and one U motor as spares for both FNAL and UCSB. Other possible failure points in the Aerotech gantry include the DR500 crate, in which the servo amps are installed, and accidental damage to the either the x or y axis glass encoder scales. For the DR500, the cost of a spare versus estimated repair time from Aerotech is now being investigated to determine if a spare should be purchased. Any glass scale repair would likely require major down time (~month). This might necessitate shipment of the gantry back to Aerotech for repair. We have asked Aerotech to consider this, and tell us what would be involved for such a problem, in terms of both money and time for repairs. More importantly we are adding awareness of this particular vulnerability to our training protocol and documentation of the gantry operators. We are also carefully reviewing and amending our procedures to minimize the possibility of this problem.

[1] A dry run is a complete assembly run, but without epoxy. Components can thus be reused.

Aerotech does not have a routine maintenance program and their extended service agreement simply provides priority service without any specific guarantees. We did not purchase the extended service agreement. In fact, it has been our experience that they have always responded quickly to our problems. As an alternative, one could buy and commission a spare gantry. The cost is close to $60K and this would involve a 12-20 week lead time. At the current time, we do not see any need to purchase a spare gantry in the US. We do anticipate downtimes for the gantry during production but these will very likely be short. We can recover from production downtimes of several days, to a week or so, by later running at peak capacity for the following weeks until any backlog is cleared. In addition, each production site has some spare capacity and can increase production while the other is down.

The gantry tooling at both FNAL and UCSB has functioned so far without major problems. The lifetime of these parts should not be an issue unless there is accidental damage, which has happened, and will probably happen again at some point. Note however that the additional E-stop switches in the gantry head for the Z and rotational axis have resulted in very little damage to the pick-up tools. The replacement of these E-stop switches could take 1-2 days. This is in fact the typical downtime for any work to be done to the U-motor shaft. Substantial re-alignment and checking of gantry parameters is always necessary in this case. Spare assembly tools are listed in the table below.

Gantry Tooling Spares	At FNAL	AT UCSB
Sensor Pick-up Tool	1	1
Hybrid Pick-up Tool	1	1
Syringe Glue Tool	2	2
Set of Z and U axis E-stop switches	1	1

The assembly plates seem to be quite robust once they have been fully commissioned. Each center has at least 2 assembly plates (and usually considerably more) for every type of module they will be producing. Problems with one assembly plate could limit production for a short period of time. Since the plates were all built at the respective gantry centers, repairs would take place on site. Below is a list of assembly plates and their status at FNAL and UCSB.

UCSB Plates	# Fabricated (parts made)	# Commissioned (ready to be used)	plates used in module production so far
TOB R-phi	7	7	7
TOB Stereo	3	3	3
TEC R5 R-phi	2	2	2
TEC R5 Stereo	2	2	2
TEC R6	5	5	5
TEC R7	2	2	2
FNAL Plates			
TOB R-phi	6	5	5
TOB Stereo	4	3	3
Total	**31**	**29**	**29**

Other possible failure modes for module production are: loss of clean room air conditioning, failure of curing vacuum pumps, and breakdown of our optical survey machine (OGP). The air conditioning is probably more critical at FNAL where large temperature increases (10-15 deg. F) result during warm months. Vacuum pump failure is more likely at UCSB where there is a pump used for the gantry and 2 more for the curing cabinet. UCSB has one spare pump and is considering purchase of a second. In the case of OGP breakdown, after-cure surveys would be done on the gantry. This would lead to a 10-15% drop in production availability of the gantry, which could in principle be recovered by extending our daily working hours.

In summary, the gantry system is quite reliable. In preparing this document of potential problems, and tabulation of spares in hand, we realized that there are a few more parts that should be purchased and others that will be considered. In the experience of building hundreds of glued and dry run modules, we have found that overlooking small details during module assembly can cause time loss that in turn can accumulate to cause significant delays in production. One unnoticed piece of kapton overlapping a sensor pad, for instance, has been known to cause 2 hours of frantic recovery work. In view of this, we will pay particular attention to the careful training and performance of the gantry technicians. Training, experience, and comprehensive written procedures are as important in limiting production delays as is the availability of back-up parts and systems.