It appears that the Batcher Memorial Website group is making a lot of progress. You may be doing this already, but frequent communication with Virginia (Ginnie) may be able to reduce the total amount of work required by coordinating your activities and hers.

The documents attached this email focus on current research that addresses the primary reason that Goodyear invested heavily in building the STARAN and ASPRO. The complexity of processing air traffic control (ATC) and related type of applications has been well-known for a long time. In particular, it has been established theatrically and is widely accepted by experts in this area that any multiprocessor solution to ATC (as well as a wide range of other challenging applications) will require exponential running time. Basically, multiprocessors are architectures with multiple processors that execute asynchronously. Instead, the STARAN, ASPRO, and MPP had multiple processors that operated synchronously, so the preceding exponential running time results do not apply to them. These types of parallel computers are called SIMD (single instruction, multiple data). At each step, all currently active processors execute the exact same command. The MPP did not have the broadcast-reduction network that allows the STARAN and ASPRO to execute ATC much more efficiently. As a result, the ASPRO with 2000 processors could manage the flight of 2000 aircraft in the same time that is required for it to manage only one aircraft. For ATC, each processor is used to manage the flight of at most one aircraft. Then code for ATC tasks such as aircraft tracking and radar correlation, collision detection, collision avoidance, terrain avoidance, etc. can be executed synchronously by all processors. For an application involving surveillance of possible enemy targets, each processor is assigned at most one target. That way, all processors can execute their code for all targets synchronously.

It appears that none of the engineers and technical staff at Goodyear Aerospace or later at Loral realized that the execution of ATC was running in linear time while the software that was used to manage ATC in the United States and elsewhere was running in exponential time. This fact was never mentioned by Ken Batcher or Jerry Potter, even after Professor Will Meilander and I started pursuing research in this area. Will Meilander was in charge of implementing ATC software for the STARAN at Goodyear Aerospace. There are several detailed documents regarding this implementation of ATC on the STARAN (including the code that Will Meilander’s team developed) in the documents produced at Goodyear that have been scanned by the Kent State Digital Library. This giant gap between the execution time of ATC when implemented using the STARAN or ASPRO and the execution time of traditional implementations was first suggested to me after Will moved from his engineering position in Goodyear Aerospace to an instructor’s position at the Computer Science Department at Kent State. He also made an extensive literature search that located theoretical papers that established all multiprocessor implementations of ATC had an exponential execution time. It is clear that the STARAN or ASPRO execution time for ATC is linear since the algorithm for each of the ATC tasks is linear. Moreover, any SIMD with an adequate number of processors can execute ATC code in polynomial time. However, in order to meet required deadlines, the SIMD needs to have an adequate number of processors and the its execution of ATC needs to be reasonably efficient. The execution complexity of ATC by a SIMD also depends upon on the type of interconnection network they have.

I am including three additional attachments that provide more information about the preceding discussion. The JPDC-2013 journal paper is an extension of a doctoral dissertation of one of my students (Mike Yuan) and provides execution times and graphs that show the ATC execution time using various architectures. This paper also has information about an ATC demonstration at Dulles airport where the STARAN was used. Additional information about both the STARAN and ASPRO is included.

Also, a recent (2018) paper is also attached. It is titled “Performance of NVIDIA accelerators with SIMD, Associative, and Multi-core processors for Air Traffic Management”. The presentation slides used at the ICPP conference are also attached and are easier to follow since they provide the major conclusions without the implementation details. The NVIDIA accelerators architectures are new architectures with a very fast clock when compared to the STARAN and ClearSpeed (a SIMD used in this comparison). While the NVIDIA accelerators were able to execute ATC in near linear time, it is clear that the execution of the STARAN is much more efficient than the NVIDIA accelerators in their execution of ATC.

These two research papers indicate that the STARAN and ASPRO computers that were developed at Goodyear Aerospace can still perform communication intensive tasks with deadlines such as ATC much more efficiently than modern architectures. Professor Gokarna Sharma and I hope to extend the results of these two papers in our future research. Research into applications which can be performed much more efficiently using a STARAN/ASPRO type of architecture rather than current architectures is potentially a new area for future research for those who find the performance of the STARAN/ASPRO on ATC to be impressive.