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STUDY OF AN AVIATION DESIGN SUPPORTABILITY COURSE FOR ENGINEERING AND TECHNOLOGY

J. Mark Thom and Tracy Gerbracht

Abstract

The following reports on a study examining a typical aeronautical/aviation engineering senior design course, and examines how an aviation technology based course applying the elements of logistics support analysis might be taught concurrently. The study examines the content of a typical senior engineering design course, the required content for a technology based logistics support analysis course, and analyzes the overlaps. Over the course of the study the methods and limitations of engineering design were observed by the technology researchers and were used to formulate the content of an aviation logistics course.

Introduction

With the dramatic revision in engineering accreditations standards created by ABET 2000 environment (ABET was formerly the Accreditation Board for Engineering and Technology), technology programs are being expected to become more integrated into the engineering efforts of industry. The applied knowledge taught in technology programs has for years filled the gaps left as engineering became more scientific and analytical, and with less hands-on application. (Thom, 2004) The experiential knowledge and skills of the technology graduate has been increasingly recognized as more and more technology programs are granted accreditation as engineering technology programs. The aircraft structures, systems, and operations knowledge taught in aviation programs in the United States today, can play an important role in engineering technology. The following study details one way in which direct aviation maintenance and operations knowledge can be used to develop synergies with the engineering design process at the educational level.

What is logistics?

Historically the discipline of logistics has been a military term, but that has changed over the last twenty years. J. W. Langford in his book *Logistics Principles and Applications* defines logistics as, “the application of engineering, operational and managerial skills to provide a product with prerequisite quality, reliability, maintainability and

supportability; and to sustain safe and cost-effective utilization of that product for its intended purpose throughout its projected service life.” There a more business oriented definition of the term has begun to emerge. In Benjamin S. Blanchard’s books *Logistics Engineering and Management* a decidedly more engineering aspect of the term can be found when he says that logistics is “a composite of all support considerations necessary to assure the effective and economical support of a system or equipment at all levels of maintenance for its programmed life cycle.” Logistics in truth covers the planning of a process or a system from inception to conclusion. It has been popularized in retail marketing by the modern method of product shipping and distribution in order to meet a zero inventory strategy, and by the “just in time for delivery” business strategy. However, shipping and distribution are only one small aspect of the concept of a forward planning supply and utilization strategy that dates back to the Roman Empire.

The elements of making logistics happen in a modern aerospace system include: definition of system requirements, training, information technology, facilities, test and measurement, support personnel, spare parts determination, supply chain and inventory, technical data, packaging and transportation, and logistics data information. (Blanchard, 2004) Each of these elements is demanding in and of its self, and if the elements are only managed

can be difficult. In the case of the design course outlined in this current study, there is little difference in experience between the engineering student and the technology student (B. Blanchard, personal communication, May 16, 2003). This is because the engineer is most familiar with the design requirements of the system but is less familiar with the operational requirements, and the technology student knows operational requirements but is less familiar with the design constraints. However in "the real world" the actual knowledge differences become more pronounced.

If an aviation technology logistics course is to be developed that would co-exist with a senior engineering design course, it is necessary to understand how the engineering design course is conducted. Much of the decision on the viability of success for a proposed concurrent logistics course depends on the interface between the logistics course and the senior engineering design course. Not only do the goals need to be similar, but also the path to reach those goals needs to be similar. If the technology based logistics course is going to study maintainability factors, then the engineering class needs to supply the maintainability data to the logistics class. It is this sort of synergy envisioned as being necessary to create the most successful relationship.

Considerations for the study

In the current study there were several considerations in making the determination of whether the logistics course could be conducted as desired. The first hurdle was the need for the logistics students to harvest useful engineering data to perform a logistics analysis. The backbone of the logistics course was the logistics analysis. This analysis drove the topics in the logistics course. It also provided immediate and useful feedback to the students, both logistic and engineering.

The second hurdle was a need for the logistics students to absorb the engineering data and provide feedback to the engineering students. Once the logistics students received the engineering data, they used that data to create an analysis. But the job of the technologist was not considered complete until some sort of feedback to the engineering students was provided. The analysis could have been a full Logistics Support Analysis (LSA) or it could have been a simple and quick comparison between two options to determine which option provided the greatest reliability, i.e. a trade study. But even the simple act of providing the results of the analysis was not enough. The results had to be provided in such a manner the engineering students could understand the relevance to the design. Complete feedback also contained proof of the validity of the results of the

logistical analysis. This way the engineering students not only knew what the impacts on the design might be, but could base decisions on the logistics feedback with confidence.

The third hurdle was the engineering student's need to obtain some benefit from the logistics support analysis provided. They needed to see if there were changes made to the design based on information provided by the logistics students. In order to expect buy in from the engineering students, the engineers needed to see how an LSA tangibly and measurably improved their design. If engineers created the best designs without logistics influence, proof of the need for logistics would be flimsy at best. One goal was to show the engineering students avenues of resources and support beyond their own discipline.

Creation of goals for the technology logistics course

The intent for logistics course resulting from this current study was several-fold. It was envisioned as a way to allow engineering and technology students to interact in order to allow the engineering students to utilize the experiential skills of the technologist. It would also allow the technology students to have first hand access to learn from the structured engineering design process. Even if the courses did not meet formally together the intent would be to be able to provide a cross flow of data to allow the engineering students to make better design decisions and to allow the logistics students to be able to work an iterative analysis that evolved as the design of the system evolved. If nothing else, the intent was to create a climate to teach both the engineer and the technologist how to communicate with one another in their respective professional languages, and to carry this skill into the aerospace design and manufacturing environment. The result of the work done by the technology logistics students would be the creation of a Logistics Support Analysis (LSA) data analysis that could detail the significant cost, manufacturing, reliability, and critical elements of the system design.

According to Blanchard (1992), there are four objectives to the Logistics Support Analysis (LSA):

- 1) Helps create the initial supportability requirements.
- 2) Helps evaluate alternative systems or equipment design configurations.
- 3) Helps evaluate specific logistic support requirements.
- 4) Measures and evaluates the operating system in terms of its effectiveness and supportability. Not only does the analysis help design a better system, but it also provides a way to evaluate the system. In this manner there is no need to "guess" if the

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system is working correctly, there is objective evidence to prove its effectiveness.

The LSA process also evaluates different system/equipment design configurations. This process might entail topics such as: alternative repair policies, specific reliability and maintainability characteristics, or comparison of two or more off the shelf equipment items to replace a unique system design (Blanchard, 1992). It is this functionality that allows logistics plans to be flexible, and prevents designers from being locked into a predetermined box. True exploration to possible dead ends can occur, and definitive answers can be given as to their potential.

Another goal of the LSA is to evaluate a design based on logistic support requirements. After design data is available, many things are able to be determined; such as test and support equipment, inventory requirements, training

requirements, personnel skills, spare and repair parts, technical data, facilities, transportation, handling requirements, and computer resources. These results are identified through the logistic support analysis record (LSAR) or the maintenance analysis documentation (Blanchard, 1992). These are the factors that, if not identified and quantified early in the design process, can spell the failure of the program.

A diagram detailing the LSA process within the system design process is included as Figure 1. Steps six, eight and eleven comprise the major logistics steps in the system design process.

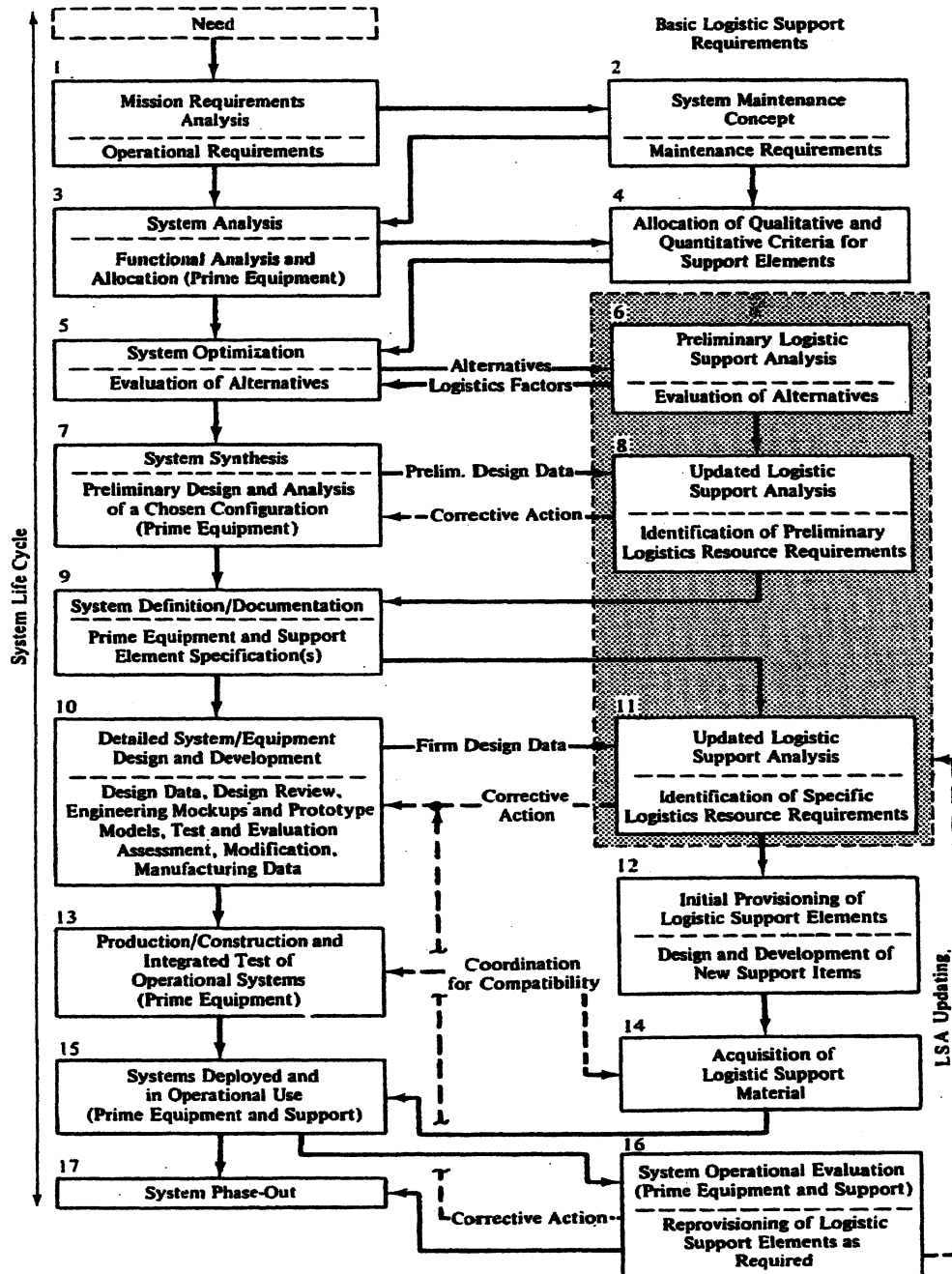


Figure 1 (Blanchard, p 19, 2004)

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Methodology

In order to identify the criteria and procedures required to construct a successful course five elementary activities were to be preformed:

1. Observe engineering design education courses directly,
2. Analyze previous design course structures and content,
3. Analyze previous logistics course structures and content,
4. Collect data from logistics text books,
5. Determination of structure, content, and goals for the proposed concurrent engineering/technology class.

Observe engineering design education courses

Much of the decision on the viability of success for a logistics course depended on the interface between the logistics course and the senior engineering design course. Throughout two semesters of studying a typical design engineering course the researchers attended all of the scheduled lectures and labs. The researchers documented the daily topics covered in the course and any problems encountered by the students. The questions asked by the engineering students were noted as well as places where the engineering students expressed a desire for logistics based information was noted. The researchers documented the daily topics covered in the course and any problems encountered by the students. This information was summarized and used to create the course comparison spreadsheet found in Appendix A.

The researchers as participants

Since the end result of the logistics course was to provide engineering students with logistics support data and to understand how they would use it, it did not seem prudent to maintain a status as silent observers. By simply observing, it would have been possible to overlook some of the problems that might be associated with trying to create an interface between logistics students and engineering students. Therefore the authors of this study, along with the two other technology based researchers, formed a logistics support team to allow the aviation technology researchers to interact with the engineering students. This team provided the engineering students with input to their designs based on the team's experience in the design and manufacturing industry. In this way the researchers could be involved in the process in a manner much like how they envisioned the future technology logistics students to interact. Based on the questions received from the students throughout the semester the engineering students found this to be a valuable

resource.

The content of the engineering courses

As seen in Appendix A, the courses all began with having the engineering students respond to a Request for Proposal (RFP), followed by having the students do trade off studies, constraint diagrams, carpet plots, and historical reviews of aircraft performance in order to settle on a basic aircraft design. The results were presented in a Preliminary Design Review (PDR). Following that, the engineering students would move on to detailed design work focusing on structures, stability, propulsion, and aerodynamics. The status of the detailed design work would be presented weekly and would culminate in a Critical Design Review (CDR). Following a successful CDR, the engineering students would be given a go ahead to either build the aircraft (subscale), or in some semesters to complete further detailed analysis of the aircraft to verify mission capability. Regardless of whether an aircraft was built or whether a detailed mission study was completed the timing and pacing of the courses remained nearly identical over the semesters examined in this study.

The engineering students were divided into design teams and the students looked at the operational requirements of the RFP. They did brief studies to determine what kind of design options might be available to fulfill the mission. These possible alternatives were presented to the course instructors in a formal presentation where the pros and cons of the alternatives were discussed. During this detailed engineering analysis period the instructors in the engineering course would work with the student groups to help them utilize the analytical tools the students had been given over their academic career. During this time there was very little detailed engineering analysis regarding structures or systems. Most of this time was spent collecting and defining performance data and the factors affecting the performance data.

In a real engineering effort there would have been some detailed design done at this point. Key technology limitations would have been identified, off the shelf or design by similarity concepts would have been identified and quantified. In an actual design effort in industry it would be this initial pass at selected detailed design which would begin locking in the costs, technology required, and limitations for construction and maintenance of the aircraft. In the student design course this data definition did not happen. The engineering students assumed that the construction technology would be available, possible, functional, and cost effective.

The detailed design work in the engineering course

often did not include significant detailed analysis of the construction aspects of the aircraft. In general, it involved gathering materials and beginning a trial and error construction of the aircraft. As the students developed skills at aircraft construction they then began to document and analyze what they considered to be the significant technological problems with the aircraft design. In the classes where no actual aircraft was built, a detailed analysis following the PDR was generally done to produce a marketability study for the aircraft or an operational assessment for the aircraft. In these cases the engineering students had little or no empirical knowledge, or understanding of how to get historical data to perform a detailed market analysis or operational assessment of the aircraft.

Each group of engineering students was expected to do a formal presentation at the end of the semester detailing their design activity. The week by week activities of these courses was detailed in the analysis spreadsheet in Appendix A.

Analysis of previous Aeronautical Engineering design classes

In addition to studying ongoing engineering design courses, the researchers gathered historical data from eight more semesters of engineering design course activities by looking at the research notes and syllabi from another researcher (Thom, 2004) who was doing a five year longitudinal study of these engineering design course activities. In this way data from these other semesters, taught by four different engineering instructors, could be compared to the semesters directly observed to determine if what was observed was typical. From these notes, which detailed the daily activities of the design course, more substantiation was gained on the activities in the engineering course in general. These activity notes from previous researchers included daily course topics, briefs on engineering students' questions, and observation data on information the engineering students desired lacked.

The summary of this work was compiled in analysis spreadsheet and included in Appendix A. The comparisons revealed that the semester studied was indeed typical of an engineering senior design course in this curriculum regardless of the semester, the projects chosen, or the instructor who taught the course.

A comparative study of previous logistics courses

Historical data was also gathered regarding the teaching of logistics courses. A series of logistics courses had been taught at the local community college for over six years. The instructors teaching in this program were adjunct instructors

who worked full time in industry performing logistics duties for aerospace companies or for U.S. defense contractors. Courses taught by more than one instructor were examined, and the information gathered reflected many semesters' worth of experiences at teaching the logistics elements. The information gathered from a review of these courses indicated in what order, and on what kind of schedule, the elements of logistics analysis should be taught.

In general, these courses were conducted in a manner consistent with the plan of study recommendations of the Society of Logistics Engineers (1992). The courses typically began with an overview of probability as a foundation for the topics of reliability and maintainability. After that the topics included aspects and measures of system availability for use. Availability topics such as mean time between failure, natural and induced failure rate, mean time to repair, and system availability were quantified. The methods for analyzing systems were developed including the factors involved in evaluating failure modes and determining criticality. Finally the methods for evaluating the cost of ownership of the systems were quantified, and methods for examining life cycle costs were established. There were no specific courses in the plan of study guides from the Society of Logistics Engineers that provided the type of concurrent course sought for this study. The plan of study guides were used in this study to extract the key concepts desired, and to try to find a way to package them into a single course compatible with being taught concurrently with an engineering design course.

Over the course of studying these course topics the logistics students were taught about the two-way links between the engineer and the technologist who often does the logistics analysis. The logistics students were taught that certain data had to come from the engineer, and that, in return, certain data needed to be made available for the engineers to use in design decisions. There was, however, little education provided to the logistics students on how the engineers used the data provided, how the engineers produced the data they supplied to the logistics process, or the limitations on the engineers in these processes. The ways that the design process worked affected the type of data the logistics analyst received. The assumptions used in the creation of the engineering data also affected the assumptions the logistics analyst should have made.

By performing the logistics analysis in a vacuum of knowledge about the engineering process, the assumptions made for the resulting logistics analysis are less accurate. Additionally, by not understanding the engineering process, the logistician can wind up asking engineering the wrong

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questions, or can ask the right questions as the wrong time. In either case the logistician may wind up unable to develop an accurate analysis.

The information gathered from a review of the logistics course is also provided in Appendix A.

Logistics text book review

The researchers conducted a review of possible textbooks for a potential logistics course. All textbooks available from text book publishers at the time were examined. This was done to find a textbook which contained information compatible with the proposed course. Secondly, this review provided input to the researchers that the content and organization of the proposed logistics course was in line with the views of well known contemporary logistics experts. The methodology of the textbook review is beyond the scope of this paper. It should be noted however that the text book eventually selected was influenced by the pattern of information taught in the engineering classes using the content and teaching patterns identified in the spreadsheet in Appendix A.

Determining the Organization of the proposed Logistics Course

Separate columns in the spreadsheet shown in Appendix A were created for the development of a new logistics course. The order and content of the information in these columns allowed for the teaching of the logistics concepts and allowed for inclusion of data from the engineering courses. Time was factored in for the technology based logistics students to gather data from engineering, perform an analysis of the data, and provide feedback to engineering. As part of the analysis process, columns were added in the spreadsheet, which included the formulaic requirements for the logistics course on a week by week basis, as well as detailed information needed to the technology based logistics students. For the purposes of this paper these detailed columns have been omitted from Appendix A for clarity.

Analysis of the design and logistics course comparisons

The spreadsheet shown in Appendix A was used as the graphical interface tool, not only to display the end data but to allow for the side by side qualitative assessment of the course contents. Analysis of the spreadsheet was done on an ongoing basis using 42-inch wide plotter outputs of the spreadsheet. Because of the limited power of a desktop computer monitor to provide a "big picture" view of a large spreadsheet, only the paper plotter versions were used in the analysis.

Appendix A shows a spreadsheet comparison of the

logistics courses and the engineering design courses laid out side by side, on a week by week schedule over a standard fifteen week semester. Appendix A is admittedly a complex document for the inclusion in this paper, and the temptation was to break up its findings, to scatter portions of it throughout this paper, and to simply summarize its findings. The authors feel however to do that would be to detract from the intent of using graphical tools to present complex information as is advocated by Dr. James Evans, in his textbooks *The Management and Control of Quality*. The spreadsheet was the heart of the study and the authors of this study felt that it was important for presentation here.

The spreadsheet compares:

- 1) Logistics courses more than five years by two different instructors,
- 2) Ten semesters of engineering courses with four different instructors,
- 3) The textbook topics available from the textbook selected,
- 4) Statements of what the students in the logistics classes were expected to know and do at prescribed times in the semester.

On paper this match up between the historical logistics courses and the historical design courses seemed to match up at an acceptable level. During the first part of the semester where the engineers were working on the system definition the technology students would be working on understanding the foundational probability elements needed for the reliability and maintainability studies to come. As the engineering students developed their first pass at a design proposal during the PDR, the logistics students would be ready to take that information and perform a low level analysis of the critical drivers in the system. By the time the engineering students reached the CDR, they would have been iterating the design and the logistics students would have been using those iterations to better define the cost and criticality elements. When the engineering students moved to the construction phase in one course or in the operational assessment phase in the second course, the logistics students would then be at work using the known data to prepare a "cradle to grave" life cycle cost evaluation of the system. The logistics students would present the life cycle analysis at the same time the engineering students performed their final flights or final operational assessments. In an ideal setting the engineering students would have logistics data to support their design decisions and to make design changes.

Limitations in the engineering process

From the time spent in the engineering design classes it

became apparent that the engineering students had a tremendous amount of information to distill in their fifteen weeks of class. Organizing and quantifying the engineering data alone was daunting for them, and given that there was often a lack of direct experiential knowledge of aircraft materials and systems their tasks became even more difficult. As the engineering students worked to gain the knowledge they needed to do their analysis it became evident that it was not possible for them to provide enough detailed data early enough in the semester to allow the logistics students to do a useful logistical analysis. Configuration control of the engineering designs was not possible at a level at which the logistics students would be able to provide feedback in a timely enough fashion to be of benefit to the design process. Ideally the courses would work in a design spiral where the engineering students develop a design, the design is analyzed, and the results of the analysis are fed back to the engineers for design modifications. The issue then became that the engineering students could not provide consistent data arrival schedules and could not provide enough detailed data for the logistics analysis. While this discovery was not anticipated it was, however, important to this study to have understood why it occurred. It was important to understand why the timeline of the engineering design course was not compatible with the timeline of the logistics course. When on paper it appeared that the two should co-exist, but in the real world they did not, an understanding of why was required. This was important not just from a theoretical standpoint. The reasons why had implications on the expectations that a logistics student would have on the engineering design process. To know the limitations of the design process allowed for better assumptions in the logistics process. Knowledge of where and how the data gaps occurred were valuable in allowing the logistics course developers understand the constraints of the engineering design process, and to be able to instill that information into the logistics course. It was just as important for the student of the logistics class to understand the limitations of the design process as it was for the engineers to be able to understand the logistics process. Armed with first hand information of the limitations of the engineering senior design course, the development of a functioning logistics course was still.

Alternatives for Engineering/Technology Interaction

The inability to operate a logistics course concurrently in parallel with a design course was anticipated from the beginning. While concurrency was a goal, it would have been naïve to have based the success of the study on that outcome. There were several options for compensating for

the limitations found in the data delivery from the engineering design course. Option one might have been to specially re-work each of the two classes into a specific design and support analysis course. But this would have affected the plans of study of two separate programs at the university. Option two might have been to force a standard structure for the engineering course that made the course dependent on the logistics analysis. But this would have required interfering with the design engineering education process, and imposing impractical limits on the design course instructors. Option three might have been to limit the scope of the engineering course to areas where data from the logistics analysis directly drove the designs. Again, that would have interfered with the engineering education. Based on direct observation of the engineering design courses these options were not advised. To shackle the design course to the logistics analysis would have taken away the inventive spirit of the design process, and limited the creativity of the engineering students. The researchers advocated instead a fourth option.

This fourth option would be to run the logistics course separate from the engineering design course. This would allow the logistics students to do an analysis on engineering designs from previous semesters where the data would be as complete as possible. While this defeated the one goal of direct engineering-technology interaction, it still provided a way to provide trusted and usable data.

The proposed solution

Instead of feeding back the results of a design analysis in the same semester, the results of these analyses could be provided back to future engineering design classes to allow them to make future design choices given historical data from previously analyzed designs. Review of historical data was stressed in engineering as one of the elements of good design in engineering. By providing analysis and data on previous semesters' designs, the future engineering students would be able to make better choices based historical data prepared by the aviation technology students. This would then in turn teach the engineering design students about the availability of the logistical data. Using the structure of the logistics support analysis would provide the validity of data discussed previously. It would provide data in a usable format compatible for easy inclusion into the aircraft design, which was one of the preferred outcomes.

A drawback of this system is that there is not the direct face to face contact between the aeronautical engineers and the aviation technologists. However, by having the aviation technologists as the authors of useful historical data for future design classes, it can prompt the engineers to seek out

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technology input in the future. For the technology students taking the logistics course without the engineers, it remains up to the technology instructors to take the knowledge gained working with engineering and impart to the technology students the design process and its limitations.

Conclusions

From a technology education standpoint, valuable information was gained about the methods and limitations of the engineering design education process. The ability to study first hand the way that the design process was taught, and the difficulties of the student engineers had in assimilating the technical pieces, provided insights into the kind of support that technology could provide to the engineering process. These insights allowed not only for the design of a logistics course, but also provided first hand information on what the role of an aviation technology program might play as an engineering technology program

in the post ABET 2000 environment. In the end it was determined that in this case the required fluid nature of the engineering classes did not provide the timeliness and completeness of the engineering data needed for a real time logistics analysis. This study advocates having the aviation technology students analyze final designs and to provide historical databases for future semesters of engineering design students to use for their required "historical analysis". Feedback gathered from the engineering design students during this study showed that they welcomed the technical and logistical inputs from the researchers who actively participated in the design processes. This indicated that the logistical inputs from the technology students would be valued and welcomed additions to the engineering design educational process. →

J. M. Thom is an associate professor at Purdue University. While there he has overseen a certificate course in logistics, has taught design life cycle cost analysis courses, and has been the principle investigator for three studies on engineering education. Professor Thom holds an A&P certificate and teaches aviation maintenance and engineering technology, and has taught graduate courses in quality management. He has worked a field engineer for a major aerospace corporation, and in design engineering and integrated logistics support activities.

T. L. Gerbracht is a customer support engineer for the Pratt & Whitney engine division of United Technologies. She has worked as a customer support representative and as a logistics engineer for McDonnell Douglas and The Boeing Company. She holds an A&P certificate, and became involved in the study of engineering technology education and the logistics processes while working to complete her Masters Degree in Technology through Purdue University.

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Appendix A

Week	Topic	Textbook "Logistics Engineering and Management"	Logistics Instructor #1	Logistics Instructor #2	Engineering Instructor #1	Engineering Instructor #2	Engineering Instructor #3	Engineering Instructor #4
1	Introduction to Logistics	Chapter: 1 Section(s): 1 - 2, 8	Mean & Median	Overview to Logistics	(8/28) Introduction to the class, mission requirements		Start up with RFP. Concept development of a/c prior to RFP	Discussion of "what is design", what is RFP. Groups given class RFP. Groups given design tasks, i.e. structures, aero, engine, etc. Teams formed
1b	Introduction to Logistics	Chapter: 1 Section(s): 3 - 4			(8/28 lab)		Deliverables stated; Market analysis for a/c. Concept definition for a/c. Concept for sizing of a/c. Report for morphing and formation a/c	Students shown: lift drag calculations. Students given equations for design, and design methodology. Shown carpet plots.
1c					(8/28)			Intro to system engineering. Concept selection criteria discussed.
2	Introduction to Logistics	Chapter: 1 Section(s): 5 & 7	Reliability & Maintainability	Measures of Logistics	(9/2) weight, mission profile, different options possible for completing the mission		How to write a business case.	Mission statement and market analysis. Business goals, assumptions and constraints given.
2b	Reliability, Maintainability, and Availability Measures	Chapter: 2 Section(s): 1			(9/2 lab) lift/curve slope, significance when it comes to numbers		Economic impact of design.	In class exercise: develop general specifications, show how specs affect design characteristics, do a functional analysis. Explanation of how different groups represent different functions, i.e. wings, propulsion, LG, etc.
2c					(9/4) what weight to design to, range concerns when it comes to LAN, marketing, endurance, cost, restrictions, reusability		Explanation of how data drives design.	Wants vs. needs explained. Formulas given for weight, stability, fuel, Bregret. Teams formed by function

Appendix A

3	Reliability, Maintainability, and Availability Measures	Chapter: 2 Section(s): 1	Availability & Quality Assurance	Measures of Logistics	(9/9) software requirements, pod, weight, Power, Propeller Efficiency, Propellers, prop=engine=aircraft, Torque, Wing Loading, Power Loading	Engineering terms and abbreviations. Set up for market analysis presentations. Students present first iteration business plans.	Lots of formulas for design given to students. Discussion of reasons why a/c sizes and shapes differ. Trade offs for performance. Sensitivity discussed; mission weight vs. performance, Budget to define mission.
3b	Reliability, Maintainability, and Availability Measures	Chapter: 2 Section(s): 2			(9/9 lab) expected life, operating time, Constraint Analysis, Stall Speed, Cruise Constraint, Endurance Constraint, Power Required	Show students how engineering concepts interact and affect each other.	TSFC - life/drag- Mn - empty weight, etc effects on sizing. Airfoil aerodynamics: lift and the different kinds of drag.
3c					(9/11) pro/con of choosing design too early, "design to what you can buy", downstream effects of chosen design	Students given sizing approaches	Groups to find weights of similar designs. Functional groups to find parameters for current design and compare to similar designs. CMARC software introduced.
4	Reliability, Maintainability, and Availability Measures	Chapter: 2 Section(s): 2	Human Factors Engineering & Safety Engineering	System Operational Requirements and System Maintenance Concept	(9/16) Aspect Ratio, Two Dimensional Airfoil Data, Drag Polars, Induced Drag, Oswalds Efficiency Factor, Wetted Area, Skin Friction Coefficient, Reynold's Number, Laminar Flow, Turbulent Flow	Students present weights vs. cost.	Fuel fractions and related concepts vs. mission constraints.
4b	Reliability, Maintainability, and Availability Measures	Chapter: 2 Section(s): 3			(9/16 lab) Team Concepts Due, group work	Discussion of what Trade Studies should consist of.	More weight vs. performance evaluations. Range vs. weight etc.
4c	Reliability, Maintainability, and Availability Measures	Chapter: 2 Section(s): 4			(9/16) team assignments, open discussion, push rods		Students iterate mission statement given what the have learned to date about their design.

Appendix A

6	The Measures of Logistics and System Support	Chapter: 3 Section(s): 1 - 3	Contracting	Functional Analysis & Requirements Allocation	(9/23) D&RO's due, propeller design parameters, propeller design software "gold.m, prob.m"	Students taught ACCENT software from Boeing and NASA.	Students presentations begin this week
6b	The Measures of Logistics and System Support	Chapter: 3 Section(s): 4 - 5			(9/23 lab) Preliminary Design Reviews	Discussion of fuselage design. Raymer does not address passenger and cargo needs well so it was defined here.	First attempts to match mission with specifications
6c					(9/25) effective presentation, antennae	(Students have no design yet at this point)	
6	The Measures of Logistics and System Support	Chapter: 3 Section(s): 6 - 7	Critical Path Analysis, WBS, & Learning Curve	LSA	(9/30) open discussion	Students are supposed to bring sketches this week. Most bring cad drawings.	Students presented information on QFD in order to organize what the customer wants and how to organize alternatives on how to achieve those wants.
6b	The System Engineering Process	Chapter: 4 Section(s): 1 - 4			(9/30 lab) Sizing Review	Student show an actual trade off study.	Students present entire concept for aircraft by function, aero, structures, propulsion, etc.
6c					(10/2) propulsion turbine vs. gas		Students generated 20 sketches of alternative designs and were required to down select.
7	The System Engineering Process	Chapter: 4 Section(s): 5 - 6					
7b	The System Engineering Process	Chapter: 4 Section(s): 7 - 9	Life Cycle Cost and Design Reviews	Test	(10/7) Dynamic Modeling Process, propeller pitch	Students are to supply basic layout, first guess at gross weight, basic shape, carpet plots, 3 view drawings	QDR formal presentations done by functional groups.
7c					(10/7 lab) Propulsion Review		

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(10/14) No Classes

8	Logistics and Supportability Analysis	Chapter: 5 Section(s): 1	Facilities and PHS&T	Logistics in System Design		Students present: layout, basic design, engine, tail shape/size, wing shape/size.	More QDR: engines, inlets, combustion chambers, turbines, thrust, metrics
8b	Logistics and Supportability Analysis	Chapter: 5 Section(s): 2			(10/14 lab) No Classes	Students present trade off studies of non performance items. Questions about whether proposed designs can actually be built. Integration of structures (wings, fuse, attach, etc.) is discussed	Discussion of matching engine to airframe.
8c					(10/16) Structures and Weights Review	Specifications for performance gains of formation flight are discussed.	
9	Logistics and Supportability Analysis	Chapter: 5 Section(s): 3	Inventory Management & Personnel Management	Test and Evaluation	(10/21) propeller pitch, control surfaces, flight control functions, Structures Review	Preliminary believable data from ACCENT begins to show up.	Groups are forced to pick one of their aircraft designs and lock it in. Formal drawings are beginning
9b	Logistics and Supportability Analysis	Chapter: 5 Section(s): 4			(10/21 lab) Aerodynamics Review	Landing gear and landing gear placement is presented.	Constrain diagrams with things like wing loading vs. thrust to weight ratios are developed.
9c					(10/23) Propulsion Review	T.O. distance is discussed. Engine integration with airframe is discussed.	Initial internal layout is presented. LG config is presented. Analysis of stability and control is discussed.
10	Logistics in System Design and Development	Chapter: 6 Section(s): 1	Logistics Technical Documentation & Support & Test Equipment	Spring Break	(10/28) Propulsion Review, trade studies	Students present stability and control information.	Students present stability and control analysis, tail size, CG, shear stress, tension and compression, aspect ratio, static margin.
10b	Logistics in System Design and Development	Chapter: 6 Section(s): 2			(10/28 lab) Structures & Weight Review	Students are to have refined all design properties: wing, tail, engine, L.G..	

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(10/30) Dynamics and Control Review

10c						Students present and get feedback on carpet plots.	
11	Logistics in System Design and Development	Chapter: 6 Section(s): 3 - 4	Embedded Computer Resources	Production and/or Construction	(11/4) walk around drawing, trade study	Students present final fixed geometry (non morphing) aircraft design configuration.	Students present weights and structures: material selection, LG placement, tire size, tail size, component weights of major units.
11b	Logistics in System Design and Development	Chapter: 6 Section(s): 5 - 6			(11/4 lab) Dynamics and Control Review		Students present summary of engine performance.
11c					(11/6) Aerodynamics Review	Formation flight for drag reduction is discussed.	Engine performance "on" and "off" design is discussed
12	Logistics in the Production/Construction Phase	Chapter: 7 Section(s): 1 - 2	Equipment Maintenance	System Operation and Support	(11/11) Individual group work	Discussion on what must be changed in basic aircraft design if formation flight becomes a customer requirement.	The RFP is linked to the QFD. The students are shown how to use the QFD to show that they are meeting the RFP needs.
12b	Logistics in the Production/Construction Phase	Chapter: 7 Section(s): 3 - 4			(11/11 lab) Propulsion Review	Students present final version of the fixed geometry aircraft.	The student make presentations of the whole design package.
12c					(11/13)	Students begin making predictions for aircraft performance in formation flight	
13	Logistics in the Production/Construction Phase	Chapter: 7 Section(s): 5 - 6	Design Interface	Open	(11/18) Structure & Weight Review	TBD	
13b	Logistics in the System Utilization, Sustaining Support, and Retirement Phases	Chapter: 8 Section(s): 1 - 2			(11/18 lab) Aerodynamics Review	TBD	The students make presentations on propulsion designs: TSFC, engine sizing, thrust, a/c velocity vs. thrust, etc
13c					(11/20) Propulsion Review	TBD	Advanced technology choices are discussed

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14	Logistics in the System Utilization, Sustaining Support, and Retirement Phases	Chapter 8 Section(s): 3 - 4	LSA & Configuration	Logistic Support Management	(11/25)	TBD	More presentations of aircraft design choices
14b	Logistics Management	Chapter 9 Section(s): 1 - 2			(11/25 lab)	TBD	
14c					(11/27) No Classes	TBD	
15	Logistics Management	Chapter 9 Section(s): 3 - 5	Test	Class Trip	(12/2) Dynamics and Control Review	TBD	Final design review. Students present everything to customers.
15b	Logistics Management	Chapter 9 Section(s): 6 - 7			(12/2 lab) Dynamics and Control Review, Structures Review	TBD	Customers include faculty panels, as well as USAF visitors.
15c					(12/4) Cost Review	TBD	

