TERMINAL COURSE OBJECTIVES (TCOs)

September, 2005

General Comments:

- *How will TCO's be incorporated?* Rule making is a long-term process, but there's a short term need in this area that can only be met by policies. This class will eventually lead to a regulation describing what training is required for practicioners. There will be an FAA policy out next year describing what must be container in courses of this nature. (per Larry I) There isn't any hard rule that says you have to take the course. Understand the need, but nobody there to make them do it! (Money based issue) Should the course be mandatory? Need to administer the policy that we have.
- *Class scope must be limited:* Modules must include only what is necessary. This class should not specify which data to be discussed. (Doug Larson) This class needs to be focused on "What you need to worry about" (Larry I) There should be a large caveat that says. "This is an overview only class." Noting that approved data must be used should be the intent of this class. Course content will be covered in different ways by different training providers. The key here is that the TCO's are covered, and that different Training Providers will achievd covering these TCO's in different ways. (Gary Oakes) Consensus needs to be developed and this course could aid in developing concensus. Keep content at interest level of audience. Keep in mind target audience: "introductory course … focused on technicians, engineers, and inspectors"; add managers, auditors, QA. Assume already familiar with repair process and metallic structure. Assume details for those doing the work will be covered in other courses. Keep short enough to make attractive - 3 days? Too much repetition - stream-line to fit in schedule.
- *Broaden Prerequisites where Possible:* Move more of the basic info to the prerequisites.
- *Identify roles relative to target audience*: (Engineering staff, quality control staff – fundamentally decide the definition of target audience.
- *How to enact these TCO's at Training Providers:* How will the content of this course be incorporated by the Training Providers if they aren't forced to by the FAA? Angie K suggested that practicioners may want to take the class voluntarily. Tim H said practicioners won't spend money for training unless forced to. The new 145 rule requires training per Rusty Jones(?), which is approved by PMI.
- *Written Text may need an iteration*: Orient written material into supporting paragraphs that detail each specific point being made. Photographs may be valuable in conveying ideas. Be careful not to use contradictory terms.

Terminology – be specific, more universal. Focus is on existing sandwich structure. Add detail on complexities of structure. Every section should focus on key issues, why they are important, and differences from metal structure

- *Demonstrate is wrong Term:* Student capabilities aren't defined. "Demonstrate" does not require that the student be able to meet the requirement. May want to change the term to "Awareness of" or "Familiar with".
- *Critical Key Process Characteristics must be clear:* Too many *Key Process Characteristics* have no relevance. Must focus on only the necessary *Key Process Characteristics*. yy
- *Composite Repair isn't Difficult, just Different.* This should be the core theme of the entire course. State this clearly up fron and keep hitting this theme throughout. "What would you want your manager to know about Composites." yy
- *Prerequisite Section May Grow:* Growing this could help consolidate the Modules. Get the person smart enough to participate in the class and ask the right questions in the class.
- *Content may shrink in Modules:* Type of instruction can be classified. Level I is teaching, Level II is show and tell, Level III is full Lab (Tim Harris). Can us cooking-show approach to demonstrations. Making couplons and buying fasteners may constrain lab content. yy
- *Equipment Operating Requirements:* Module B should discuss what parameters the equipment should operate under. Calibration of equipment, etc. Describe why these requirements are important. Describe how to check each piece of equipment for compliance. Improper handling and storage could be addressed.
- *Edge damage and delamination* processing may nedd to be discussed here.
- *Terminology will be consolidated:* Authorizing Documentation will inclide SRM, 8110's, and Repair Work orders. Bleeder vs. Breather cloth (dilineate between where the same material is used two different ways.)
- *Personnel Certifiaction:* Does it make sense to have repair certification for Composites Repair Technicians? Level I, II, III Certifications. Maybe similar to welders. The use industry standards (American Welding Bureau). Maybe a secondard Liscense system (Al Riffal). Possibly use apprenticeship model for certification. Otherwise have a practical and written examination. Who is training the FAA – they may be sending their people (auditors) to this class. (Jolene)

TCO F Module – Describe Composite Laminate Fabrication and Bonded Repair Methods

General Comments:

- *Discuss fiber/resin volume* - impact on strength, wet lay-up versus prepreg resin content, resin started with vs. bleeding. Tolerance Range isn't defined by SRM's.

- *Class Duration could be Shorter:* Content plus lab – 3 to 5 days individual labs (shorter broadens audience) Tendency in content is to have too much depth
- *Bag has to be sealed* – in relation to condensation. Not mentioned in module.
- *CoCuring and CoBonding discussion:* This could be moved to glossary or Prerequisite.
- *Step Sanding vs taper sanding* could be mentioned. This could be added to the Glossary or Base Knowledge
- *Ply Thickness Differential:* It needs to be mentioned that a thicker stack-up isn't a one for one thickness exchange. Ply stackup will be thicker than parent component. (Often a 0.002 thickness increase per ply even under the best vacuum bagging.) yy
- *Repairs may not require ply for ply replacement.* "What works" is really what will be prescribed. This isn't always one-for one. yy
- *Non-Parent* materials are also acceptable if allowed in the repair spec.
- *Mositure Meters:* State of the art meters are improving. We may want to add a section in Prerequesites that describes moisture meters. Still must perform drying per repair documentation.

F1: Understand the basics of composite laminate fabrication

- *Move Background detail to Prerequisites:* move p1 and 2 to TCO A, and combine and move F1 and F3 laminate fabrication/MRB to TCO A. Repair process – Referenced in general module; detail should be in TCO F.
- Add bullet for difference between Co-curing vs.. co-bonding
- *Not all parts are cured in an autoclave.* Must add Oven curing, etc.
- Bonded parts are tricky when components move during cure.

F2: Understand the basics of composite bonded repair

- *Molds aren't addressed well enough.* Talk about how molds must meet aero requirements and not exceed preload. DER Repair does not always use approved tooling. Form, Fit and Function don't require a certified tool.
- *Repair categories should be deleted* because the key characteristic is the requirements of the material being called out.
- *Vacuum Bagging Inconsistencies:* Inconsistencies in how vacuum bagging and DVD is described. Better to describe this in only one module, then reference that section in other modules. Might try to use the CACRC spec rather than SRM.
- *Ambient Pressure Cures:* Some repairs are acceptable with alternative consolidation techniques. This includes vacuum bags, sand bags and no pressure methodology. These must be called out in the repair documentation.
- *Vacuum Bagged Repairs have higher Porosity:* Non-Autoclave process like Vacuum bagged hot bonding generate more than 2% porosity. This will have an effect on allowables, so authorizing document will reflect this difference. "Repair Documentation" is a possible term (Tim Harris)
- *Repair materials are chosen for a reason:* Authorizing document will specify wthat to use. This subject should be covered so that the practicioners will know why specific material is called-out.

- *Scarfing needs to be highlighted as a very critical process step*. We won't teach perfect scarfing, but rather emphasize how important proper scarfing is.

F3: Describe the detailed processing steps necessary for laminate fabrication {factory}, bonded repair {maintenance base or line station}, and Material Review Board {OEM}

- Repair steps can occur in parallel

F4: Describe key characteristics and processing parameters for laminate fabrication

- Condensation on prepreg is bad. Explain
- Cure cycle controls time and temperature and vacuum/pressure.
  - Cure variables must be monitored, including temperature, time, and vacuum.
  - Thermocouple quantity and placement is critical to ensure uniform heat. Aware of heat sinks.

F5: Identify typical processing defects which occur in composite laminate fabrication and bonded repair

- Tooling needs and limitations
  - Warpage caused when heat softens the resin and then force applied by vacuum bag, without enough structure remaining to resist the force.
  - Local heating to avoid softening surrounding structure
  - Access to both sides preferred for bagging, inspection, etc.
  - Aware of sub-structure
- *Hole Drilling is different for Bolted Composite* Repair than for Aluminum. Composites require only Class Ic holes (net to +0.003) rather than transition fit holes. yy
- Discuss contamination sources
- *Porosity with composites is an issue:* (honeycomb, wet lay-up); defining level is easy to do. Porosity should be calibrated through design allowables, or adjust thickness of repair. Establish acceptable porosity limits in source documents, or tell how to spec for it or tell what acceptable limit. NDI method will allow you to inspect for it, but inspectors are not comfortable with it. Adequate debulking during lay-up is a key processing characteristic for reducing porosity.

F6: *[LAB #1]:* Damage laminate coupons in a controlled laboratory environment and visually inspect the extent of the front and any back side surface damage

TCO G Module – Perform a Bonded Composite Repair

General Comments:

- Too much emphasis on bolted repairs

G7: Describe differences between 'wet layup' and 'prepreg' bonded repairs to sandwich and laminate parts

G1: Demonstrate/apply common drying and surface preparation techniques, and how to inspect for acceptability

- Drying thick laminates can be very time-consuming and uncertain. Follow source data for acceptable drying times.

G2: Demonstrate and apply material lay down and compaction processes for a simple laminate panel repair.

G3: Demonstrate how to prepare and cure a simple bonded repair to a laminate panel, and explain the types of errors to avoid

G5: *[LAB #3]:* Prepare bonded repair for cure, including bagging & heating apparatus & cure

G4: Describe process parameters which affect bonded repair quality, and in-process controls necessary to avoid defects

- Stress key characteristics affecting repair quality
  - What are they?
  - Fiber type and orientation
  - Cure temp/time
  - etc?

G6: Demonstrate critical in-process quality controls during laboratory bonded repair process trials

- Co-curing versus co-bonding differences

G8: Describe metal bond repairs and differences from composite bonded repairs

TCO I Module – Describe Composite Laminate Bolted Assembly and Repair Methods, and Perform and Inspect a Bolted Composite Repair

General Comments:

- *Show and Tell could be more time/cost effective:* Show and tell could be used instead of Lab. Don't replace Lab with just Video. yy
- *Hole size and drilling issues* – too much depth for survey course; reference engineering documents and source documents.
- *Costs of Equipment:* Look at costs for equipment for training course
- *Lab:* Hands-on Lab Instead of instructor Demo
- *Damage Tolerance Analysis.* Needs to be addressed in TCO I2.

- *Lab costs should be low:* Expensive training will reduce the number of attendees. Equipment and other costs must be tallied to determine how much the class will cost. Value of learning must be weighed against cost of Module. yy

I1: Describe the basics of composite bolted structural assembly. Show the differences between composites and metal bolted assembly

- Move basics to prerequisites

I2: Describe the basics of composite bolted repair. Show the differences between drilling and cutting composites and metals

I3: Demonstrate composite drilling versus metal drilling

- Combine Issues with drilling metal and composites together

I4: Describe process parameters which affect bolted composite repair quality and in-process controls necessary to avoid defects

- Awareness of different failure modes and quality

I5 [LAB #5]: Demonstrate and apply common damage removal, surface preparation, drilling and fastening techniques used for bolted composite repairs and how to inspect them for acceptability

- Preparation of holes before installation
- Demonstration might be easily replaced by video or photos.

I6 Verify correct fastener selection, inspect drilled holes, and check if fasteners were properly installed during bolted composite repair laboratory trials

- Complete inspection criteria for fasteners is beyond scope of this course.