TECHNICAL REPORT WRITING GUIDELINES

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1.0 The Function of Technical Reports

A significant part of the routine work performed by LAA Engineering, involves the reviewing and checking of technical information submitted by applicants for new designs or modifications.

The clarity with which this information is presented and the ease with which it can be understood has a major part to play in determining how long it takes to carry out these reviews. Of course, the longer it takes to review one report, the later we are able to start on the next one for the next project.

We see a wide spread in report quality, ranging from beautifully illustrated works of art, to a few scribbled lines on a scrappy sheet of paper, not necessarily even written in English! Whilst we do not need to raise the level of all reports to that of the professional standards achieved by our best applicants, improving the quality of the worst reports will have a large cumulative effect on the amount of new designs and mods that we are able to process.

When a new design is approved, the reports' job is not over. They become a permanent part of what is known as the Type Record of the design. The Type Record includes all drawings, build manuals and other relevant documentation that describes the precise configuration of the design, the reasoning behind why that design is the way it is, and how it meets the applicable requirements. The report may have to be reviewed several times again throughout the life of the design, perhaps by LAA (or even CAA or EASA) staff who were not employed (or perhaps even born) when the original design was approved. They may need to assess the impact of a proposed mod on the original design, or even be involved in an accident investigation looking for potential design errors. In the latter case, the report could even be used as evidence in court. LAA Engineering reserve the right to reject reports which are not of sufficient quality to be included in the Type Record. Non-compliance with the following guidelines may result in a report not being accepted.

All of this means that you should never assume that the person who reads your report will be familiar with your aircraft, any discussions or correspondence that you may have had with anyone else or your reasoning behind anything that you have done. It should be a self-contained record of all the information that you are trying to get across. This Technical Leaflet is intended to provide guidelines to achieve this aim. A lot of the issues addressed in preparing reports in this way will also aid the applicant in self-checking the accuracy of their own work, and perhaps avoid making costly and time-consuming (or even dangerous!) mistakes.

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2.0 General Report Formatting

All reports should be translated into English.

2.1 Language

All reports should be translated into English.

2.2 Presentation

The report should be in easily readable handwriting or typeface. If the submission is photocopied or reproduced in some other way, care must be taken to ensure that the copies are readable (e.g. not too faint) and that no information has been cut-off from the edges of the original.

2.3 Issue Control

The report should have a date on it. This should be changed each time the report is updated and re-submitted to LAA Engineering. It is often useful to give it a version number as well. Reports can be submitted in electronic formats (.doc or .pdf) if the version number or date can be included in the filename, but once again should be changed every time a new version is submitted.

When additional information is inserted into a report, or existing information is revised or corrected, the whole report should be re-issued instead of just submitting new or replaced pages. In this way each issue of the report will constitute a self-contained document and anyone reading it will not have to hunt around to find what updated pages need to be read in conjunction with the original issue.

When up-issuing a report, it is helpful to include a note of how it differs from the previous issue, so that the whole report doesn't have to be rechecked.

2.4 Aircraft Configuration Control

The reports must refer to the configuration of the aircraft for which the Permit is being sought. If the report was generated when only an early prototype of the aircraft existed, it must be re-issued for the production version if there have been any subsequent changes.

It will be difficult and time consuming for LAA Engineering to assess the configuration of the aircraft without a set of clear engineering drawings defining dimensions, materials, assembly details etc. A build manual is usually not sufficient, on its own although it will provide useful back-up information to a drawing set. Photographs of the aircraft at various stages in the build also provide useful supporting information.

2.5 Section Numbering

The report should be divided into numbered sections, with a contents page at the beginning. See the layout of this leaflet for section numbering guidance.

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2.6 References

Whenever a number, quantity or dimension is quoted, the source of the information should be referenced. Perhaps it was taken from a drawing, from another report, from a reference book, or from an e-mail (quote the date or maybe include a copy of the e-mail as an appendix to the report). Wherever it came from, the reviewer will want to be able to check the source, see if it is copied over correctly, or even comes from an appropriate and accurate source.

If a given reference is used more than once it can be listed in a separate references or applicable further documents section in the report, and given a number. Then every time it needs to be referred to in the body of the text, just the number needs quoting instead of the whole reference title. (e.g. “See Ref 4”).

If the number is generated in an earlier section in the same report, the location (section number) of its origin should be given. The report will not always be read in its entirety from start to finish, so the reviewer may not be aware that the data had been previously created.

Where several numbers are used repeatedly throughout the report, it may be worth creating a section where all of these numbers are listed together, along with their references. They can all then be checked just once, at the same time. An example would be a section listing critical aircraft dimensions, such as wingspan, wing chord, tail arm etc. or a material properties section, where all the materials used in the report are described and referenced in one place.

3.0 Loads and Stress Reports

Applied load calculations for the aircraft, and stress reports where the effect of the aforementioned loads on the aircraft structure, should be contained in separate reports. Where the loads are called up in the stress report, a reference to the appropriate issue and location in the loads report should be supplied.

When loads are calculated, the relevant requirement (i.e. within CS-VLA, BCAR Section S, FAR 23 etc.) should be stated.

3.1 Diagrams and Pictures

The use of diagrams and pictures is strongly recommended. These can be scanned excerpts from drawings, or sketches, pasted into the report. Annotations and arrows can be added using the Draw facility in MSWord or Excel. Complete (not-to-scale) diagrams can easily be created using Draw.

In stress reports, free-body-diagrams (showing all the forces on a component) aid reviewing and also help the author to determine that no relevant forces or moments have been omitted.

Photographs can also be scanned, and Draw used to add notes, or additional geometry to the picture.

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3.2 Load Paths

When stressing the load path should be followed all the way through assembly, addressing each potential failure mode in turn. This approach helps to ensure that no component or failure mode is missed. Any assumptions made on load split, if the structure is redundant, should be listed and justified.

3.3 Use of Equations

Where a calculation method or equation is used, the source reference for it should be quoted. If it is an uncommon reference then it is useful if a scanned copy of the relevant pages or excerpts is appended to the report.

Equations should be written out in full, prior to use, and a definition of each variable (including the units to be used) should be given.

If the calculation method has a simplifying assumption inherent in its use, then this assumption should be stated and it should be shown how this assumption is valid for the case in question.

When equations are re-arranged, and/or combined with other equations, all the steps in the re-arrangement should be given. If terms are omitted as being insignificant or irrelevant, then a statement should be made about why this is the case.

3.4 Material Properties

The source of all material properties used (especially strength allowables) be quoted.

Strength allowables should ideally come from sources of known statistical confidence, such as Mil-Hdbk-5, ANC-18 or ESDU. LAA Engineering Technical Leaflet T.L. 1.16 contains approved conservative material data for minor modifications.

Material properties may also be generated by testing. In this case, a test report, fully describing the tests, should be referenced and made available. When embarking on a material test program, LAA Engineering should be notified in advance, of the proposed program, for approval.

Catalogue values for material properties are not acceptable without approval from LAA Engineering. When approval is granted, it will usually be associated with large knock down factors. This is particularly so with composite materials.

3.5 Reserve Factors

Where Reserve Factors (or Margins of Safety for U.S. reports) are presented, they should be clearly highlighted and the failure mode in question identified. Where it is deemed that the adequacy of component can be seen without analysis being performed (known as “Passed by Inspection”) this should be stated and the rationale behind the decision explained.

An RF Summary showing all RF’s less than 2, should be included as a separate section at the beginning of all stress reports. It should include the components names and details of the failure modes.

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3.6 Use of Spreadsheets or Computer Programs

Spreadsheets are extremely useful for performing repetitive calculations, whilst reducing the possibility of arithmetic errors. They can, however, be black boxes that are impossible to check. If a table of results is presented on its own, there is no way of seeing how those numbers were generated. The mathematics and logic behind the numbers is hidden in the spreadsheet cells.

For this reason, a sample manual calculation should be supplied, using the same maths as the spreadsheet, for one or more of the cases listed in the spreadsheet results. This manual calculation should show how all the equations are used, and should list any assumptions made, in the usual manner. This performs two functions. It shows how the spreadsheet works, and gives a check that the spreadsheet actually gives the same answer as an independent calculation performed in the same way. This will establish if there are any typos in the spreadsheet cell formulas. This is known as validating the spreadsheet.

When a report references a spreadsheet, the filename of the spreadsheet should be identified, and a soft copy submitted to LAA Engineering as a form of appendix to the main report. Issue control should be exercised over the spreadsheet, with the filename containing an indicator of the version number, which needs to be changed each time it is re-issued.

If a company, or applicant, wants to use the same spreadsheet again and again, it is permitted to perform a validation of the spreadsheet in a separate report. Each time the spreadsheet is used, the report in which it is called up simply needs to reference the spreadsheet validation report.

Care needs to be exercised to ensure that the logic of the pre-validated spreadsheet is not changed in between uses, or a repeat validation will be required. A reference copy should be kept by the applicant, with an identical one held by LAA Engineering, with the cells locked, except for accepting new data inputs.

As a point of interest, it is possible to format a spreadsheet, in portrait page setup, so that it can be printed out to look exactly like a report. All the textual content and diagrams or illustrations can be included as usual. With care, if all the variables within the report are linked, an entire stress report can be created which will automatically update itself, when dimensions or the aircraft weight, for example, are changed.

A similar approach is required to validating any computer programs used, whether written by the applicant, or another party. An independent manual check calculation must be provided. Several different cases should be checked manually if the software is third party. If the program is not third party, but the applicant is responsible for it, then a copy of the equations, and algorithms that describe how it works, should be submitted. Source code listings can also be submitted as part of the validation and LAA Engineering will treat these as “commercial-in-confidence” if required.

Input and output text files can be included in the report as appendices.

Like spreadsheets, frequently used programs may be pre-validated in a separate technical report.

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4.0 Finite Element Analysis

Finite Element Analysis is being increasingly used by applicants, to generate stress data, or internal load distributions to allow subsequent detailed manual stress analysis. FE models represent a somewhat extreme case of the use a computer program, and hence are treated specifically in more depth here.

Two aspects of the analysis have two be addressed. Firstly, the validity of the FEA package itself. That is, if the input data is correct, does the package actually return correct results.

The second aspect is whether or not the input data is correct, and the modelling idealisation assumptions are appropriate.

4.1 FE Package Validation

The name of the package and the version number should be recorded in the report, along with details of the computer platform and operating system that the analysis was performed on. For accepted industry standards packages, such as NASTRAN, ANSYS, STRAND7, etc, LAA Engineering will at their discretion accept the validity of the package.

For less well known packages, or for more complex types of analyses, such as non-linear buckling, a validation check of a simple model against closed manual calculations will be required.

4.2 Input/Output Data Checking Strategies

Assessing the validity of the input data and idealisation assumptions made in generating a model is less simple and requires quite a lot of data to be supplied in the report. Copies of text input and output data files can be appended to the report, if not prohibitively large. Alternately these can be provided as computer files, with the issue controlled filenames referenced in the report.

An alternative approach could be for the LAA Engineering reviewer to actually be able to interrogate the FE model for input data and post-processing output data. We are able to accept models created in STRAND7. Alternatively, if it can be arranged in the UK, we could sit with the FE analyst for a model reviewing session, on their own installation of the FE package.

4.3 Geometry and Geometric Idealisations

The input units system must be identified. Plots of the model geometry, from all angles, should be supplied. A full justification of all geometric idealisations must be given. (i.e. beam, thick or thin shell or solid model, geometric details omitted).

The node numbers of significant locations (such as attachments or load extraction points) should be listed.

The model global co-ordinate system, and any local systems defined for the application of loads and constraints (or results extraction) must be identified.

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4.4 Material Properties

The material properties used in the model should be listed. Shell thicknesses and applied beam properties should also be identified and the beam property generation calculations included. If possible, screen plots of material type and shell thicknesses should be provided. Beam orientation plots should also be provided for non-symmetric beam sections.

If material densities are used to generate model mass for inertia load cases, the resulting model mass and CG location must be compared with those actually required.

4.5 Constraints

The location and degrees of freedom of all constraints must be identified, and justifications provided. Screen plots, confirming the constraints applied, should be included if possible. The same applies to internal degrees of freedom within the model, such as beam end releases or shell edge hinge freedoms.

Deformed geometry plots should be included in the results to allow checking that the constraints are performing as expected in limiting model movement.

4.6 Loads

The load types and magnitudes applied to the model must be identified and justified. Whenever possible, screen plots showing the applied load directions and magnitudes for each load case, should be included.

To confirm that all loads (particularly pressures and inertias) have been applied correctly, the sum of the output reaction loads and moments should be presented, and compared with the applied input loads.

4.7 Results Output

Results plots should be taken from sufficient directions and with sufficient close-ups to enable the relevant aspects of the results to be seen. If a shaded image helps to understand the deformed shape, this should be used instead of wireframe. The author should look at the plots provided and try to decide if they enable someone with no knowledge of the analysis, to understand the results.

Stress and Deformation contour or fringe plots should be included in the report (as an appendix if there are a large number). If these are colour plots, then they should be reproduced in colour, or level labels added to the plot!! (Can't believe we've had to say that, but it is a frequent error in submissions).

Discreet colour bands should be used for fringe plots. Extended spectrum plots (where all the colours merge smoothly into each other), whilst looking impressive, are useless for practical results post-processing.

If possible, peak or other significant, stress or deformation labels should be included on the plots, to allow the precise values to be confirmed by the reader.

If stress values are to be used from the model, a discussion should be presented on the convergence of the model. This is the influence of the mesh size on the peak stress results. Some indication of convergence can be obtained by plotting discrete stress contours with the

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results at the element edges unaveraged. A poorly converged model will show jagged steps in the contours where they cross. A full convergence analysis requires the model to be re-run with a progressively refined mesh in the area of interest, until the peak stress is unchanged between runs.

Convergence has a lesser effect on deformations or constraint loads, but can still be significant.

When loads are extracted from the model, if possible, a plot showing the load at the required location, on screen, should be included.

It must always be stated in which co-ordinate system all results have been extracted.

5.0 Test Reports

5.1 Loading Information

The overall loads on the aircraft or assembly should be calculated in the separate loads report. Any detailed calculations on how the loads are to be applied on the test rig may be contained in the test report.

The actual loads and distribution applied during the test must be recorded, and compared with those required to meet the applicable requirement.

5.2 Test Sample Description

The test sample, must represent in all relevant features, the structure of the design being qualified. Any changes, however small, from this standard, must be identified in the report, so that the reviewer can assess their relevance.

The moment arm sizing calculations for Whiffle Trees should be included in the report.

5.3 Test Equipment Description

A full description of all the test equipment must be provided, describing in detail how the loads are applied, and how the test sample is restrained. Photographs and dimensioned drawings or sketches should be used to support this description. Any load application or measuring equipment should be listed and described.

5.4 Test Method

The test procedure should be fully described, identifying points at which the structure was unloaded and inspected for permanent deformation. The locations and way in which measurements are made must be recorded.

5.5 Raw Test Results

All raw, unprocessed results and measurements must be included. If this constitutes a lot of data it may be included as an Appendix, or presented as a separate computer data file or spreadsheet, under issue control and referenced from the main test report.

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5.6 Photographs During Test

As many photographs as practically possible should be taken during the test, from all angles. Specific photographs, such as those at limit or ultimate load conditions, showing deflections, should be included in the report. It is useful if a placard or sign is displayed in photos of these significant events, showing the load achieved. Other miscellaneous photos should preferably be provided in digital format on a CD or similar media.

Videos should be taken of dynamic tests, such as landing gear drop tests, and ideally presented in digital format.

Photographs of any failures or permanent deformations should be taken and included in the report.

When taking photos, it should be remembered that it is of interest to ascertain if the test rig starts to support the test sample in an inappropriate manner as the sample deflects.

5.7 Results Post-Processing

It is frequently required to carry out post-processing calculations on raw measured results data. This could be for example, converting measured linear deflections to angular deflections, or converting pressures from a hydraulic ram into applied loads. These calculations should be included in the report, maybe as an appendix. They should be reported in the same manner as other stress calculations (see above), including the treatment of any spreadsheets used.

5.8 Conclusion Statement

A clear statement of the findings of the test should be included, along with any additional significant observations, recommendations or discussions.

5.9 Equipment Calibration

Proof of calibration must be included for all measuring equipment. It can be in the form of formal calibration certificates, or calibration confirmation test reports. This information may be included as an Appendix.

5.10 Systems Tests

Systems tests, such as fuel flow tests, should be reported with similar rigour to that described above for structural tests.