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→ **ESA-APPROVED SKILLS TRAINING SCHOOLS**

Electronic Assembly Techniques

B.D. DUNN

Product Assurance and Safety Department
ESA/ESTEC TEC-Q

STR-258
November 2008

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Abstract

This report describes the various activities that skills training schools undergo to gain and maintain an ESA approval for the training and certification of inspectors, instructors and electronic assembly operators. The training courses are in accordance with the electronic assembly standards and process specifications used by European space projects. Outlines of the course contents are given and the tools needed for these manufacturing processes are described. The courses also provide a basic understanding of the use of materials in the space environment.

The report also harmonises the approach and technical content of the various training courses offered by ESA-approved skills training schools, the types of certification awarded to successful candidates, and the means of progressing or retaining their certified status.

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1. Introduction

As part of its activities to promote, improve and maintain the quality of work within the space industry, the Product Assurance and Safety Department of ESA (TEC-Q) operates a scheme for the approval of centres to train and certify operators, inspectors and instructors in electronic assembly in accordance with appropriate standards. Manufacturing and assembly methods applied within the space industry for spacecraft electronics are detailed in the various process specifications cited herein.

In developing skills training schools, ESA's goals are to:

- Develop a pool of personnel trained in best practices for electronic assembly
- Develop a network of organisations capable of providing training to appropriate standards.
- Improve the quality of electronic assemblies used in space projects

These goals are achieved by:

- Provision of high-quality training in electronic assembly techniques at ESA-approved training schools
- Assurance that operators, inspectors and instructors obtain a level of technical knowledge and experience through training to enable certification.
- Harmonisation of the general policies between schools, notably courses and examinations, by means of the ESA annual skills training schools meeting
- Continued monitoring, assessment and audit of approved schools by an ESA-nominated manager.

2. Scope

This document describes the various activities necessary to become and maintain an ESA-approved skills training school for the training and certification of inspectors and instructors, along with electronic assembly operators in accordance with the applied standards and process specifications cited herein.

3. Abbreviations

CAT	Category
ECSS	European Cooperation for Space Standardization
ESA	European Space Agency
ESTEC	European Space Research and Technology Centre
MIP	Mandatory Inspection Point
NCR	Non-Conformance Report
SMC	Surface Mount Components

4. Related Documents

Skills-training schools establish and maintain an effective written programme to train, certify and recertify all personnel performing any operations described in one or more of the standards and process specifications listed in Table 4.1.

Always establish that the version of a standard or process specification is the most recent issue.

ECSS-Q-ST-70-07	Verification and approval of automatic machine wave soldering
ECSS-Q-ST-70-08	The manual soldering of high-reliability electrical connections
ECSS-Q-ST-70-18	The preparation, assembly and mounting of RF coaxial cables
ECSS-Q-ST-70-26	The crimping of high-reliability electrical connections
ECSS-Q-ST-70-28	The repair and modification of printed-circuit boards and solder joints for space use
ECSS-Q-ST-70-30	The wire wrapping of high-reliability electrical connections
ECSS-Q-ST-70-38	High-reliability soldering for surface-mount and mixed-technology printed circuit-boards
ECSS-Q-70-51 DRAFT	The termination and splicing of optical fibres, fibre optic cables, cable assembly and installation [this standard and the related course are under development]

Table 4.1 – Electronic assembly standards and process specifications

5. Skills Training School Scheme

5.1 Approval

The ESA-nominated manager has the final authority for granting, extending, reducing or removing the approval status of a skills training school.

5.2 Skills Training Schools

To be granted or to maintain the ESA-approved status, each training school undergoes an assessment of their training facilities (see 6.1) and undertakes to:

- Provide a business plan
- Make available staff credentials and school records for assessment and monitoring visits (see Annex 1 and 2)
- Submit an outline for each course that meets ESA's demands (see Annexes 3 to 8)
- Describe corrective action to resolve non-conformances
- Maintain resources, facilities, records and provision of training

5.3 Certification: Categories and Personnel

5.3.1 Categories

Only three types of certification are awarded under the skills training school scheme, as given in Table 5.1.

Category	Title	Conditions of award [†]
Category 1	ESA-Approved Instructor and Examiner	Certificate can only be issued at the present time by ESA-approved skills training schools
Category 2	Inspector	Certificate can only be issued at the present time by the ESA-approved training schools or by an ESA contractor's in-house school where the instructor and examiner have been certified according to Category 1
Category 3	Operator	Certificate can only be issued at the present time by the ESA-approved training schools or by an ESA contractor's in-house school where the instructor and examiner have been certified according to Category 1
[†] See 5.9 for list of ESA-approved skills training schools		

Table 5.1 – Certification: Categories and conditions of award

5.3.2 Certificates

Each training school issues certificates in two formats which are standardised across training schools:

- full A4 page size for display purposes.
- ‘credit card’ size, carried by certified personnel to enable identification at the place of work

(See Annex 2 for an example of a certificate.)

When operators are certified to perform limited operations or processes, it is stated on the certificate and on the personal certification card, along with all associated certification records.

Each certificate is approved by the signature of the Training School Manager. Category 1 Certificates are countersigned by the ESA-nominated manager.

Certificates are usually valid for a period of not more than two years (see also 5.3). The issue and expiry dates are shown on the certificate.

The period of two years can be extended by up to 6 months due to unavailability of recertification classes.

5.3.3 Certified Personnel

Certified Category 1 personnel are responsible for the training, certification and recertification of Category 2 and Category 3 personnel. Category 1 personnel are authorised to train inspectors and operators employed by their organisation.

Certified Category 2 and Category 3 personnel perform inspections and processing operations respectively, at the site of any ESA contractor.

ESA prime contractors, which provide in-house skills-training courses for the certification of inspectors and operators, have at least one Category 1 instructor and examiner for each of the processes used by the contractor (see 4 – Related Documents).

For ESA contracts, the initial training of every operator and inspector is undertaken at one of the approved schools (see 5.9). Recertification can be performed by in-house ESA-certified Category 1 instructor.

5.3.4 Progression of Certified Personnel

Figure 5.1 shows the progression route for certification of personnel. All personnel undergo operator training (CAT 3) prior to advancing to inspector level (CAT 2) or Instructor/Examiner (CAT 1) level.

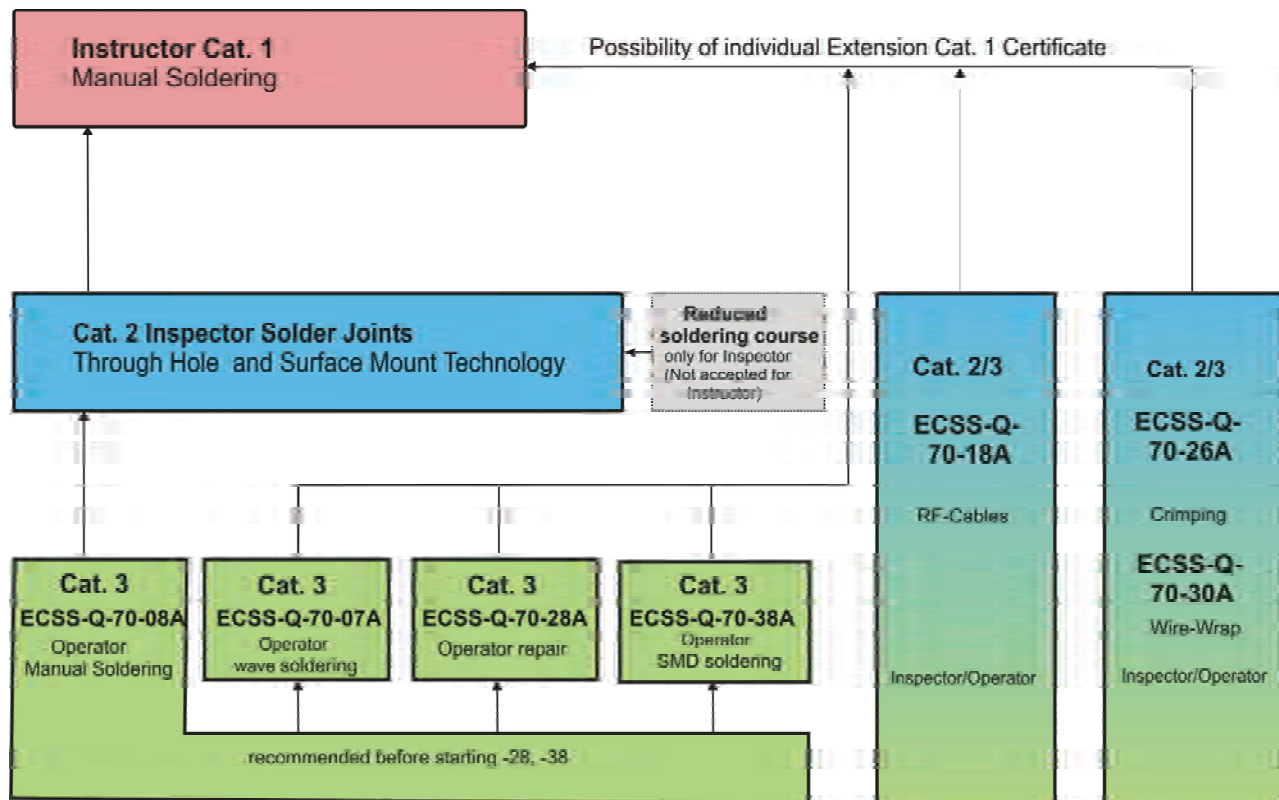


Figure 5.1 – ESA Training Structure – Progression route for certification

5.4 Visual Acuity

All candidates undergo eye tests as part of certification:

- Far vision: SNELLEN chart 6/15 metric or better
- Near vision: JAEGER 1 or 0.50 mm letters at 35.5 cm or better
- Colour perception: Normal as determined by means of standard colour plates. i.e. Dvorine pseudo-isochromatic plates, Ishihara plates or equivalent.

All eye tests are undertaken by an accredited eye examiner. Eye tests are performed annually for persons 35 years of age or older, and every two years for persons less than 35 years of age.

Failure to meet visual acuity standards results in disqualification of a candidate for training, certification or recertification.

For colour perception testing, a practical test using colour-coded wires and/or colour-coded electrical parts, as applicable, can be used. It is clearly stated on the certificate issued if a candidate fails this test.

Prescription lenses are used for process operations or inspection, but are not necessary when a binocular microscope with individually adjustable eyepieces is used.

5.5 School's Training Records

The school's training records are maintained as stipulated in a particular ESA contract or, if not stated, for a minimum of five years.

The training schools records comprise:

- Trainee fabricated test specimens depicting satisfactory conformance to the applicable process specification.
- The marked written test papers
- Details of the employer and employer's address
- Certification Category
- Date of certification or recertification
- Records of the latest visual acuity examination (eye test)

5.6 Training Programme Evaluation

The training programme, the associated skills-training facilities, training records and the trainee testing are reviewed by the ESA-nominated manager to assure that each programme is compatible with the relevant standard or process specification (see Annexes 3 to 8 for details of each training course outline).

Approval of a training programme can be withdrawn at any time in the event of a non-conformance.

5.7 Maintenance of Certified Status and Recertification

Instructors, inspectors and operators need to demonstrate continuous proficiency and a high standard of workmanship in order to maintain their status of certification.

Recertification of personnel is necessary in the following circumstances:

- Insufficient proficiency for a particular standard or process specification.
- There is a reason to question proficiency of workmanship
- Development of new techniques that need new skills
- If less than two years since last certification, personnel may attend a recertification course to have their certification extended for a further two years.
- If there is a lapse of more than two years after recertification then the full course has to be attended. Recertification is only possible within the two-year lapse-period. During the lapse-period operators/instructors are not considered to be certified unless they have already arranged a 6-month extension (see 6.3).
- Operator personnel experience a work-period interruption greater than six months (responsibility of the employer).

5.8 Withdrawal of Certified Status

Certifications issued by the school are revoked in the following circumstances:

- The certificate holder is not recertified within the stated time period
- The certificate holder fails the visual acuity tests (see 5.4).
- Non-conformance of a school's training programme.
- The quality of work does not meet the standard or process specification (responsibility of the employer).

5.9 Certification Sources

Table 5.2 lists ESA-approved training schools for the certification of personnel (as of 2008).

Of these, Category 1 certification is only awarded by schools marked †. Certification of Category 2 and 3 personnel can also be accomplished at in-house (company) training schools (see 5.3).

Denmark	Hytek Sofievej 61 DK-9000 Aalborg	Tel. (45) (9811) 7003 Fax. (45) (9633) 2201 Contact: Mr. P. Juul
France	Institut de Soudure (IS) – Department Formation ZI Paris Nord 2 – BP 50362 F-95942 Roissy CDG Cedex	Tel. (33) (1) 49903622 Fax. (33) (1) 49903659 Contact: Mr. Y. Jouffrey
Germany	IFE [†] Sollachweg 3 D-82234 Oberpfaffenhofen	Tel. (49) (8153) 1433 or 281422 Fax. (49) (8153) 3241 or 28243 Contact: Mr. G. Kudielka
	ZVE [†] Argelsrieder Feld 6 D-82234 Oberpfaffenhofen	Tel. (49) (08153) 40320 Fax. (49) (08153) 40315 Contact: Mr. K. Ring
Italy	Italian Institute of Welding (IIS) Lungobisagno Istria 15A I-16141 Genova	Tel. (34) (010) 8341315 or 834110 Fax. (39) (010) 8367780 Contact: Mr. L. Moliterni
UK	Portsmouth University [†] Portsmouth PO1 3DJ UK	Tel. (44) (023)92846451 Fax. (44) (023)92842351 Contact: Mr. W. Strachan
† Approved school for Category 1 certification (as of 2009)		

Table 5.2 – ESA-approved training schools for electronic assembly techniques

6. Approval of Training Schools

6.1 Application for Approval

To apply for ESA-approval, a potential skills training school submits the following information to the head of ESTEC Product Assurance and Safety department:

- Geographical and language coverage of the applicant school.
- An assessment of the potential market for the school in terms of sustainability.
- An assessment of whether the school has access to the resources (human and physical) needed in order to meet the standard.
- Documented procedures and instructions relating to the operation of the training programme.

An assessment of the information provided is undertaken by ESA in order to approve a new school.

6.2 Surveillance and Monitoring

6.2.1 Periodic Surveillance

The periodic surveillance of the skills training school is conducted in the same way as the original assessment, but can concentrate on particular aspects as a result of information received with respect to performance.

Both ESA-approved schools and in-house training schools operated by an ESA instructor are visited at least once every four years by the ESA-nominated manager.

6.2.2 Investigation of Complaints

Complaints are grouped as either:

- A trainee complaint about a skills training school
- A failure traced to unsatisfactory work by a certified operator or inspector.

In the second case, it is the responsibility of the employer and/or ESA, based on objective evidence related to mandatory inspection points (MIPs) and non-conformance reports (NCRs).

In both cases the ESA-nominated manager investigates the complaint and reports back to the skills training school and the complainant regarding the action to be taken to resolve the issue.

6.3 ESA Approval, Change and Withdrawal of Approval Status

6.3.1 ESA Approval

Based on a review of the school's documentation and an ESA audit, approval is granted:

- After an assessment has been carried out.
- If the skills training school has passed and there are no major actions outstanding

Approval is awarded in the form of a letter signed by the ESA-nominated manager, giving

- Details of the skills training school, e.g. name of school and abbreviated address.
- A list of courses

6.3.2 Extension

A skills training school applies to extend its training portfolio (scope) by submitting details of a new course to the ESA-nominated manager for assessment.

6.3.3 Reduction

The approval scope can be reduced either by the skills training school (notification to ESA-nominated manager in writing), or as a result of complaints and surveillance visits.

The scope can be reduced if:

- The capability of a skills training school has been reduced in terms of training personnel or facilities
- Corrective actions with respect to a particular accreditation have not been satisfactorily implemented

6.3.4 Withdrawal

Approval can be withdrawn either by application from the training school in writing, or as a result of complaints and surveillance visits:

- The skills training school loses its training staff or closes
- Assigned major corrective actions with respect to the provision of the training service have not been cleared as agreed with the ESA-nominated manager.
- The skills training school manager or deputy does not attend the annual skills training schools meeting (see also 8).

7. Annual Skills Training School Meeting

All issues relating to the skills training school approval scheme are addressed at the annual skills training schools meeting. This is attended by representatives from all approved skills training schools.

The ESA-nominated manager organises the meeting and sets the agenda. Minutes of the meeting are produced and distributed to all attendees.

8. Maintenance of Records by ESA

8.1 Assessment Records

ESA generates and maintains a file for each skills training school comprising:

- Application for approval
- Visit report and associated checklists and records of corrective action clearance
- Surveillance and associated corrective action clearance records
- Applications for extensions to approved scope and associated visit reports and records
- Correspondence related to approval
- Copies of approval letter

8.2 Certified Operators and Inspectors List

Each skills training school generates and maintains a list of certified operators, inspectors and instructors (see 5.5).

In the event that the approved scope of a skills training school is reduced or withdrawn, this list is submitted to the ESA-nominated manager who undertakes to contact the employers of the certificate holders to propose an alternative skills training school for the timely maintenance of their certification.

8.3 Certified Instructors List

A list of Category 1 certified instructors is generated, maintained and published by the ESA-nominated manager. In addition he or she signs each certificate awarded to a Category 1 instructor along with the applicable skills training school representative.

Category 2 and 3 certificates are signed only by the representative of the skills training school.

ANNEX 1

CHECKLIST FOR THE ASSESSMENT, AUDIT AND MONITORING OF ESA-APPROVED SKILLS TRAINING SCHOOLS (Electronic Assembly Techniques)

1) INTRODUCTION

This document serves as a checklist for the assessment, audit and monitoring of ESA-approved skills training schools (Electronic Assembly Techniques). Audits are undertaken at least once every four years.

2) ADMINISTRATION

ESA 'Assessor' for the Training School Accreditation Scheme is:

Training Centre contact (present during assessment/audit):

Name of Centre (School):

Address of Centre:

Contact details: Telephone:

Fax

E-Mail:

Date of Visit/Audit:

3) DESCRIPTION OF CENTRE

a) Managing Director of Centre:

ESA-School Manager:

Staff details:

b) Centre is accredited for training in accordance with the following Process Standards:

c) ESA-Approved Instructor(s) and Examiner(s) are employed by the Centre:

d) Teaching infrastructure/classrooms are adequate:

- e) Facilities exist to cover the teaching of each Process, these include:
 - the written methods (procedures),
 - suitable equipment,
 - well maintained tools,
 - adequate stocks of materials and components and
 - examples of acceptable/rejected workmanship described in the process standards:
- f) Course Outlines exist describing: aims; experience and pre-requisites; duration and syllabus per day:
(Note preferred individual course outlines are distributed by ESA as shown in Annexes 3 – 8 of this document)
- g) ESA-approved examination suggestions are followed; for instance the questions on CD and the training school printed circuit board.
- h) Course fees are established and appropriate:

4) RECORDS

- a) School maintains records of personnel training and performance for at least 10 years:
- b) Visit verifies candidates for certification meet ‘Visual Acuity’ (eye-test) requirements:
- c) Details of the employer together with either the employer’s address or the address of the candidate:
- d) Certification category attained:
- e) Date of certification or re-certification:
- f) Marked written test papers (examination) exist and are suitably filed:
- g) Trainee-fabricated test specimens exist and are suitably stored:
- h) Information regarding withdrawal of certified status (see also 7b):
- i) A list of Certified Operators and Inspectors exists:

5) CERTIFICATES

- a) Certificates having ESA-agreed layouts and logos are issued to operators, inspectors and instructors who have successfully completed the individual courses:
- b) Details of the courses (processes, standard identification) and completion dates are stated on the certificate:

c) Authorisation signatures exist on the certificates:

6) ADDITIONAL FACTS

a) Courses are presented in which language(s):

b) Centre has adequately assessed the marketing of courses (related to sustainability of school):

c) A website or booklet summarising the ESA-approved course outlines exists: This should contain a description of what is meant by Certification to Categories 3, 2 and 1; any pre-requisites for the candidates; the course fees, addresses of local hotels or residences and details of the preferred means to reach the Centre (including a local map).

d) Centre has the resources (human and physical) to meet the standards:

e) The School Manager or deputy has attended the Annual Skills Training School Meeting:

f) A list of Certified Instructors (Category 1) is forwarded to the ESA Service Manager or his Secretary:

7) INVESTIGATION OF COMPLAINTS

Have formal complaints been received:

a) Where a trainee complains about a Training School:

- ESA Service Manager will take action and may withdraw School Certification.

b) Where an employer informs the school about unsatisfactory work performed by a certified operator or inspector (e.g. related to space hardware failures, rejected workmanship at mandatory inspection points (MIPs) or non-conformance reports (NCRs):

- ESA School Manager will take action and may withdraw operator or inspector certification

8) SUMMARY OF FINDINGS AND CORRECTIVE ACTIONS NECESSARY

9) CONCLUSION TO THIS ASSESSMENT, AUDIT AND MONITORING EXERCISE

Based on this Assessment Report, the ESA Assessor recommends to the ESA Accreditation Authority:

AWARDS ESA ACCREDITATION to the Skills Training School

AWARDS AN EXTENSION to the scope of the training provided by the School

REDUCES OR WITHDRAWS the accreditation provided by ESA to the School:

10) SIGNATURES

Audit assessment carried out by

(ESA nominated assessor):

in the presence of (School Manager):

Date:

ANNEX 2

EXAMPLE OF ESA CERTIFICATE



ANNEX 3

ESA Course Outline: Hand Soldering Operator ECSS Standard ECSS-Q-ST-70-08

This ESA-approved course provides basic information on the use of materials in the space environment and develops the practical skills and theoretical knowledge necessary to fulfil the task of ESA Soldering Operator. These requirements are designed to ensure process consistency and acceptable workmanship standards resulting in the production of high-reliability hand-soldered connections.

ECSS-Q-70-08 "Manual Soldering of High Reliability Electrical Connections" forms the basis for this course. This course is intended for Production Operators. Engineers and Technicians from Quality Assurance, Design and Manufacturing can also benefit from the course. The course provides practical hands-on experience. All necessary tools and equipment are supplied, although delegates are welcome to bring their own hand tools if desired.

1. COURSE AIMS

- To review and understand the requirements of ECSS-Q-ST-70-08
- To identify the factors which influence the quality, reliability and performance of a solder joint
- To develop correct hand-assembly methods and reliably produce joints to the standards demanded by ECSS-Q-ST-70-08
- To develop ability to examine and analyse faults associated with solder joints in accordance with ECSS-Q-ST-70-08

2. EXPERIENCE AND PRE-REQUISITES

- familiarity with electronic components and assembly processes
- good practical skills and soldering experience
- a positive attitude to high quality workmanship
- A visual acuity certificate according to this document.

3. COURSE CONTENT

DAY 1

- Complete the Student enrolment form
- Provide Visual Acuity test certificate
- Introductions & orientation, including safety, facilities, routines and break times
- Course introduction: what we will be studying, how, why and when
- Review of specification framework: relevant ECSS standards; release status and how to access them
- **ECSS-Q-70-08 Study:**
 - **Section 1 Scope.**
 - **Section 3 Terms & Definitions**
 - **Section 4 Principles & prerequisites**
 - **Section 5 Preparatory conditions**
 - **Section 6 Materials selection**
 - **Section 7 Preparation for soldering**
 - **Practical exercise:** this is a good point at which to demonstrate the use of cutters, strippers, anti-wicking tools and solder pot for the preparation of lengths of wires; the class can then prepare their own wires for subsequent terminal soldering exercises.

DAY 2

- **ECSS-Q-70-08 Study (continued):**
 - **Section 8 Preparation for soldering**
 - **Section 9 Attachment of conductors to terminals, solder cups and cables**
 - **Practical exercise:** this is a good point at which to demonstrate the soldering of previously prepared wires to terminals; silver-plated terminals to be pretinned, with excess solder being wicked off before wire attachment; the class can then commence terminal soldering exercises: side route turret, side route bifurcated, pierced, hook and solder cup.
 - **Practical exercise:** this is a good point at which to demonstrate the soldering of a 'shield splice' to a cable shield ; the class can then repeat the exercise.
 - **Section 10 Soldering to terminals and PCBs**
 - **Section 11 Cleaning of PCB assemblies**
 - **Section 12 Final Inspection**
 - **Section 13 Verification**
 - **Section 14 Quality Assurance**

- **Annex A: Typical satisfactory and unsatisfactory solder connections**
- **Multiple-choice operator test:** All students are required to achieve a minimum of 80% in the 50-question, open-book multi-choice question paper.

DAYS 3 & 4

- **Practical exercises (Assembly onto ESA-approved PCB):**
 - 3 large axial-leaded components
 - 3 small axial-leaded components (glass bodied) using various stress-relief forms and spacing
 - 3 radial-leaded components (horizontal and vertical mounting)
 - 3 metal-can (eg TO92) components using appropriate lead forms
 - 2 DIL components, one mounted on a high-heat-capacity site
 - Solder terminal to board using Sn96 solder, then solder wire(s) to it using Sn63 solder and necessary heat sinking to avoid remelt of the Sn96
 - Solder wire tails from above terminal, into plated through holes
 - Solder shield splice assembly to surface pads and PTH on PCB.

The instructor will monitor each student's progress in order to avoid discovering any deficiencies 'at the last moment'. Corrective instruction will be given as required. Once the instructor is satisfied that the operator has reached an acceptable standard, an Inspection Report sheet will be provided. The operator will then clean the board and commence 'own-board inspection'.

DAY 5

- Complete own-board Inspection
- Review own-board inspection with Instructor
- Undertake rework as required

4. AWARD

In accordance with this document, an ESA approved, category 3 Certificate will be awarded on successful completion of the course.

The authorisation is valid for two years (see note concerning 6-month extension under **RECERTIFICATION** below).

5. DURATION

4½ days (plus ½ day if required for re-sits).

6. RECERTIFICATION

To renew certification for a further two years, attendance at a two-day recertification course is required. The period of two years can be extended by up to 6 months if it is not possible to attend prior recertification classes.

ANNEX 4

ESA Course Outline: Hand Soldering Inspector ECSS Standards ECSS-Q-ST-70-08, ECSS-Q-ST-70-38

This ESA-approved course develops an understanding of, and an ability to interpret, specifications covering high-reliability and high-quality electronic assemblies, and ensures that sufficient knowledge is gained to make confident decisions within the parameters of the specifications with an understanding of the use of materials in the space environment.

These requirements are designed to ensure process consistency and acceptable workmanship standards resulting in the production of high-reliability hand-soldered connections. ECSS-Q-ST-70-08 "Manual Soldering of High Reliability Electrical Connections" and ECSS-Q-ST-70-38 "High-reliability soldering for surface-mount and mixed technology" form the basis for this course.

This course is intended for Production Inspectors, and for Operators wishing to extend their certification to Inspection. Engineers and Technicians from Quality Assurance, Design and Manufacturing can also benefit from the course. The course provides practical hands-on experience. All necessary tools and equipment are supplied, although delegates may bring their own hand tools if desired.

1. COURSE AIMS

- To review and understand the requirements of ECSS-Q-ST-70-08
- To review and understand the requirements of ECSS-Q-ST-70-38
- To identify the factors which influence the quality, reliability and performance of a solder joint
- To make a range of solder joints and understand hand-assembly methods necessary to produce reliable assemblies in accordance with ECSS-Q-ST-70-08 and ECSS-Q-ST-70-38
- To develop ability to examine and analyse faults associated with solder joints in accordance with ECSS-Q-ST-70-08 and ECSS-Q-ST-70-38
- To be able to inspect and evaluate electronic assemblies according to ECSS-Q-ST-70-08 and ECSS-Q-ST-70-38

2. EXPERIENCE AND PRE-REQUISITES

- familiarity with electronic components and assembly processes
- good practical and observational skills
- a positive attitude to high quality workmanship
- possession of a Cat 3 ESA certificate is desirable
- A visual acuity certificate according to this document.

3. COURSE CONTENT

DAY 1

- Complete the Student enrolment form
- Provide Visual Acuity test certificate
- Introductions & orientation, including safety, facilities, routines and break times
- Course introduction: what we will be studying, how, why and when
- Review of specification framework: relevant ECSS standards; release status and how to access them
- **ECSS-Q-70-08 Study:**
 - **Section 1 Scope.**
 - **Section 3 Terms & Definitions**
 - **Section 4 Principles & prerequisites**
 - **Section 5 Preparatory conditions**
 - **Section 6 Materials selection**
 - **Section 7 Preparation for soldering**
 - **Practical exercise:** this is a good point at which to demonstrate the use of cutters, strippers, anti-wicking tools and solder pot for the preparation of lengths of wires; the class can then prepare their own wires for subsequent terminal soldering exercises.

DAY 2

- **ECSS-Q-70-08 Study (continued):**
 - **Section 8 Preparation for soldering**
 - **Section 9 Attachment of conductors to terminals, solder cups and cables**
 - **Practical exercise:** this is a good point at which to demonstrate the soldering of previously prepared wires to terminals; silver-plated terminals to be pretinned, with excess solder being wicked off before wire attachment; the class can then commence terminal soldering exercises: side route turret, side route bifurcated, pierced, hook and solder cup.
 - **Practical exercise:** this is a good point at which to demonstrate the soldering of a 'shield splice' to a cable shield; the class can then repeat the exercise.
 - **Section 10 Soldering to terminals and PCBs**
 - **Section 11 Cleaning of PCB assemblies**
 - **Section 12 Final Inspection**
 - **Section 13 Verification**
 - **Section 14 Quality Assurance**
 - **Annex A: Typical satisfactory and unsatisfactory solder connections**
 - **Multiple-choice operator test:** All students are required to achieve a minimum of 80% in the 50-question, open-book multi-choice 70-08 question paper.

DAYS 3 & 4

- **ECSS-Q-70-38:** a study of the requirements of ECSS-Q-ST-70-38 * Passive and Active SMCs * Substrates * Stress Relief * Component Placement and Reflow Methods * Inspection * Cleaning *
 - **Multiple-choice operator test:** All students are required to achieve a minimum of 80% in the 25-question, open-book multi-choice 70-38 question paper.
- **Practical exercises (Assembly onto ESA-approved PCB):**
 - 3 large axial-leaded components
 - 3 small axial-leaded components (glass bodied) using various stress-relief forms and spacing
 - 3 radial-leaded components (horizontal and vertical mounting)
 - 3 metal-can (eg TO92) components using appropriate lead forms
 - 2 DIL components, one mounted on a high-heat-capacity site
 - Solder terminal to board using Sn96 solder, then solder wire(s) to it using Sn63 solder and necessary heat sinking to avoid remelt of the Sn96
 - Solder wire tails from above terminal, into plated through holes
 - Solder shield splice assembly to surface pads and PTH on PCB.

The instructor will monitor each student's progress in order to avoid discovering any deficiencies 'at the last moment'. Corrective instruction will be given as required. Once the instructor is satisfied that the student has reached an acceptable standard, an Inspection Report sheet will be provided. The student will then clean the board and commence 'own-board inspection'.

Note that Inspector-only candidates do not require reaching flight standard for their solder-assembly ability.

DAY 5

- Complete own-board Inspection
- Review own-board inspection with Instructor
- Complete sample-board Inspection
- Review sample-board inspection with Instructor

4. AWARD

In accordance with this document, an ESA approved, category 3 Certificate will be awarded on successful completion of the course.

The authorisation is valid for two years (see note concerning 6-month extension under **RECERTIFICATION** below).

5. DURATION

4½ days (plus ½ day if required for re-sits).

6. RECERTIFICATION

To renew certification for a further two years, attendance at a two-day recertification course is required.

The period of two years can be extended by up to 6 months if it is not possible to attend prior recertification classes.

ANNEX 5

ESA Course Outline: RF Cable Assembly Operator ECSS Standard ECSS-Q-ST-70-18

This ESA-approved course is designed to teach the practical skills and theories associated with the solder assembly, formation and preconditioning of semi-rigid RF cables. The course is based on the Solder Assembly requirements of ECSS-Q-70-18, "The Preparation, Assembly and Mounting of RF Coaxial Cables".

This course is intended for Production Operators, Quality Assurance Engineers and Design and Manufacturing Engineers. The course provides practical hands-on experience. All necessary tools and equipment are supplied, although delegates are welcome to bring their own hand tools if desired.

1. COURSE AIMS

- To review and understand the requirements of ECSS-Q-ST-70-18.
- To identify the factors which influence the quality, reliability and performance of the assembly and its solder joints.
- To develop appropriate skills and correct hand assembly methods.
- To be able to examine and analyse faults associated with the assembly.

2. EXPERIENCE AND PRE-REQUISITES

- Unless otherwise agreed, delegates shall already possess ESA-approved certification for Hand Soldering to ECSS-Q-70-08.
- A visual acuity certificate according to this document.

3. COURSE CONTENT

DAY 1

- Complete the Student enrolment form
- Provide Visual Acuity test certificate
- Introductions & orientation, including safety, facilities, routines and break times
- Course introduction: what we will be studying, how, why and when
- Review of specification framework: relevant PSS and ECSS specifications; release status and how to access them
- Presentation of ECSS-Q-70-18; multiple-choice operator test
- All students are required to achieve a minimum of 80% in the 50-question, open-book multi-choice question paper
- Check tools & RF Toolkit
- Cable forming
- Cable preconditioning
- **Dimensional checking**
- Degolding & pretinning

DAY 2

- Connector types
- Soldering methods
- Connector & dielectric trimming
- Centre pin soldering
- Degolding connector body
- Cable construction

DAY 3

- Own-work Inspection
- Review own-work Inspection
- Section end product if appropriate
- Clean-up & Check Tools
- Certification

4. AWARD

In accordance with this document, an ESA approved, category 3 Certificate will be awarded on successful completion of the course. Candidates already holding a valid category 2 Inspector's certificate will be eligible to receive a category 2 certificate for this subject.

The authorisation is valid for two years (see note concerning 6-month extension under **RECERTIFICATION** below).

5. DURATION

2½ days (plus ½ day if required for re-sits).

6. RECERTIFICATION

To renew certification for a further two years, attendance at a one-day recertification course is required.

The period of two years can be extended by up to 6 months if it is not possible to attend prior recertification classes.

ANNEX 6

ESA Course Outline: Surface Mount Assembly Operator ECSS Standard ECSS-Q-ST-70-38

This ESA-approved course develops an understanding of the practical advantages to be gained in designing and building using surface mount technology. The course has a practical bias including hand soldering as well as the methods of applying solder paste and available reflow heat sources. The course follows the requirements of ECSS-Q-ST-70-38, "High-reliability soldering for surface-mount and mixed-technology".

This course provides practical hands-on experience. All necessary tools and equipment are supplied.

1. COURSE AIMS

- To review and understand the requirements of ECSS-Q-ST-70-38.
- To develop the skills required for successful placement and hand soldering of leaded and leadless surface-mount components
- To identify methods of applying solder paste and gain practical experience of metered dispensing
- To become familiar with a range of reflow heat sources and their effect on the solderability of surface mount devices
- To demonstrate the advantages of surface-mount assembly.

2. EXPERIENCE AND PRE-REQUISITES

- Intended for Production Operators, Quality Assurance Engineers and Design and Manufacturing Engineers.
- Non-holders of ESA Hand Soldering Certificate to ECSS-Q-ST-70-08 take the 4½ day course.
- Holders of ESA Hand Soldering Certificate to ECSS-Q-ST-70-08 take the 3½ day course.
- A visual acuity certificate according to this document.

3. COURSE CONTENT

Day 1 (for non-70-08-certified delegates)

- Complete the Student enrolment form
- Provide Visual Acuity test certificate
- Introductions & orientation, including safety, facilities, routines and break times
- Course introduction: what we will be studying, how, why and when
- Review of specification framework: relevant ECSS specifications; release status and how to access them
- ECSS-Q-70-08: review entire specification

DAY 2

- Items 1–4 above for newly-arrived delegates
- Presentation of ECSS-Q-70-38; multiple-choice operator test:
All students are required to achieve a minimum of 80% in the 50-question, open-book multi-choice question paper (this will consist of 25 questions selected from the 70-08 question set and all 25 questions from the 738 question set).

DAY 3

- Syringe, screen or stencil?
- Solder paste dispensing
- IR profile check
- Paste reflow characteristics
- Pretinning
- Component placement & reflow
- Effects of varying belt speed and zone temperatures
- Reflow soldering with hot air
- Component designations
- Selection of Metcal, Pace & Weller tips
- Hand soldering leadless passive devices
- Hand soldering leaded surface-mount devices

DAY 4

- Complete hand-soldering exercises
- View Inspection slides
- Own-board Inspection

DAY 5

- Complete own-board Inspection
- Review own-board inspection with Instructor
- Undertake rework as required
- Clean-up & Check Tools
- Certification

4. AWARD

In accordance with this document, an ESA approved, category 3 Certificate will be awarded on successful completion of the course. Candidates already holding a valid category 2 Inspector's certificate will be eligible to receive a category 2 certificate for this subject.

The authorisation is valid for two years (see note concerning 6-month extension under **RECERTIFICATION** below).

5. DURATION

3½ days (plus ½ day if required for re-sits) or 4½ days (plus ½ day if required for resits) as defined above.

6. RECERTIFICATION

To renew certification for a further two years, attendance at a 2-day recertification course is required.

The period of two years can be extended by up to 6 months if it is not possible to attend prior recertification classes.

ANNEX 7

ESA Course Outline: Crimping and Wire-Wrapping Operator or Operator/Inspector ECSS Standards ECSS-Q-ST-70-26 & ECSS-Q-ST-70-30

This ESA-approved course provides basic information on the use of materials in the space environment and is designed to teach the practical skills and theories associated with the Crimping and Wire Wrapping Processes. The course is based on ECSS standards ECSS-Q-ST-70-26 "The Crimping of High-Reliability Electrical Connections" and ECSS-Q-ST-70-30 "The Wire Wrapping of High-Reliability Electrical Connections".

This course is intended for Production Operators. Engineers from Quality Assurance, Design and Manufacturing also benefit from the course. The course provides practical hands-on experience. All necessary tools and equipment are supplied, although delegates are welcome to bring their own hand tools if they wish.

1. COURSE AIMS

- To review and understand the requirements of both ECSS standards.
- To identify the factors which influence the quality, reliability and performance of Crimped and Wire Wrapped connections.
- To develop correct assembly and testing methods.
- To develop ability to identify and analyse faults associated with these termination methods.

2. EXPERIENCE AND PRE-REQUISITES

- Familiarity with electronic wiring and assembly processes
- Good practical skills
- A positive attitude to high quality workmanship
- A visual acuity certificate according to this document.

3. COURSE CONTENT

DAY 1

- Complete the Student enrolment form
- Provide Visual Acuity test certificate
- Introductions & orientation, including safety, facilities, routines and break times
- Course introduction: what we will be studying, how, why and when
- Review of specification framework: relevant ECSS standards; release status and how to access them
- Theory of solderless connection methods
- Knowledge of critical parameters affecting quality and function of connections
- Advantages and disadvantages of these process techniques compared with soldering
- Presentation of ECSS-Q-ST-70-26; multiple-choice operator test
All students are required to achieve a minimum of 80% in the 25-question, open-book multi-choice question paper
- Tools & gauges
- Crimp formats
- Wire and terminal selection and preparation
- Tensile testing sample connections

DAY 2

- Dispersive crimping
- Use of spreadsheet; variance and process capability
- Analysis of results
- Compactive crimping
- Analysis of results
- Presentation of ECSS-Q-ST-70-30; multiple-choice operator test
All students are required to achieve a minimum of 80% in the 25-question, open-book multi-choice question paper
- Wire-Wrap Tools
- Wire-wrap posts and wire selection
- Wire Wrapping
- Logging and analysis of results

DAY 3

- Own-work Inspection
- Clean-up & Check Tools
- Certification

4. AWARD

In accordance with this document, an ESA approved, category 3 Certificate will be awarded on successful completion of the course. Candidates already holding a valid category 2 Inspector's certificate will be eligible to receive a category 2 certificate for this subject.

The authorisation is valid for two years (see note concerning 6-month extension under **RECERTIFICATION** below).

5. DURATION, SCHEDULE & FEES

2½ days (plus ½ day if required for re-sits).

6. RECERTIFICATION

To renew certification for a further two years, attendance at a 1-day recertification course is required. The period of two years can be extended by up to 6 months if it is not possible to attend prior recertification classes.

ANNEX 8

ESA Course Outline: Instructor/Examiner CATEGORY 1

This ESA-approved course develops the practical skills and theoretical knowledge necessary to fulfil the task of ESA Category 1 Instructor / Examiner.

1. COURSE AIMS

- To review and understand the content of ESA STR-258
- To build on existing knowledge of those specifications that the delegate will be required to instruct. These will be taken from the following: ECSS-Q-ST-70-08, 70-18, 70-26, 70-28, 70-30, 70-38
- To develop instructional and demonstration skills
- To enable the delegate to manage a training course, its documentation and the archiving of records and certificates.

2. EXPERIENCE AND PRE-REQUISITES

- An ability to instruct, demonstrate and present
- Possession of a Category 2 and at least 3 Category 3 certificates (each of which shall have been gained within the last 4 years)
- A Visual Acuity certificate according to this document.

3. COURSE CONTENT

Week 1

- Introduction and selection of Demonstration and Mini Lecture subjects
 - Presentation of ECSS-Q-ST-70-08; multiple-choice operator test
 - Presentation of ECSS-Q-ST-20-09; multiple-choice inspector test
 - Presentation of ECSS-Q-ST-70-38; multiple-choice test*
 - Presentation of ECSS-Q-ST-70-28; multiple-choice test*
 - Presentation of ECSS-Q-ST-70-18; multiple-choice test*
 - Presentation of ECSS-Q-ST-70-26; multiple-choice test*
 - Presentation of ECSS-Q-ST-70-30; multiple-choice test*
- * according to those subjects that the delegate will be required to instruct.

Week 2

- Instructor Skills presentation with review of ESA STR-258, ECSS-Q-ST-70 and Q-ST-70-71; multiple-choice test
- Practical assembly exercises as required by each operator course (see individual course descriptions) to be delivered by the delegate
- Prepare practical demonstrations
- Practical demonstrations for each subject to be delivered by the delegate
- Prepare mini lecture
- Present mini lecture on chosen subject

4. AWARD

Upon successful completion of the course, an ESA Certificate authorising the holder to instruct and examine in selected subjects, will be prepared. This certificate will be submitted to the ESA-nominated schools manager for validation. After validation, the certificate will be sent to the delegate.

The authorisation is valid for two years (see note concerning 6-month extension under **RECERTIFICATION** below).

In order to include PSS/ECSS subjects other than ECSS-Q-ST-70-08 within their authorisation, the delegate shall show the relevant certificates on entry to this course. Alternatively, the delegate will provide acceptable evidence of ability and knowledge of the additional subject prior to enrolment.

Additional subjects can also be added after Category 1 certification.

5. DURATION

8½ days (plus ½ day if required for re-sits).

6. RECERTIFICATION

To renew certification for a further two years, attendance at a 5-day recertification course is required.

This renews all subjects listed on the Category 1 certificate (and any other subjects gained since the last Instructor / Examiner course). The period of two years can be extended by up to 6 months if it is not possible to attend prior recertification classes.

