eurocomp
The newsletter of the Space Components Steering Board

Introduction

This, the fourth issue of *Eurocomp*, the Newsletter of the Space Component Steering Board (SCSB), is about continuity. In the first three issues, the organisation behind this publication and the progress of and developments in the various activities were presented.

As we begin the new millennium, the activities coordinated by the SCSB and its subgroups, the Components Technology Board (CTB) and the Implementation Team (IT), in the latter half of the previous decade are continuing. You will therefore find a description in this issue of the Hybrids and Micropackaging Technologies dossier, one of four integral elements of the five-year strategic plan.

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The effort to strengthen the quality infrastructure with new standards is also continuing. The details given in this issue of a specialist working group on component reliability attest to this, describing the intention behind this effort and the basis for the group's work. For the brief period that the group has tried to address the means to a European reliability application, it has received an imposing mandate and has already attracted much attention both here in Europe and more internationally. In future issues, we hope to provide news from more of these specialist working groups.

In addition, a new ECSS standard for the de-rating of components is under development. A brief summary here will serve to familiarise us with its background and main features.

This issue of Eurocomp also revisits the European Preferred Parts List (EPPL) and ESCIES, the electronic information-exchange system. Both of these systems have been in operation for more than a year now. Their continued success speaks volumes about the spirit of cooperation among the partners striving to achieve strategic goals on behalf of the European space component industry.

The 5-Year CTB Strategic Plan
- The Hybrids, MCM, Interconnections and Packaging Dossier

Many different types of electronic hardware, such as telephones, radios, television sets, computers, etc., have become part of our daily lives, and these objects are becoming smaller and lighter with every product generation. Driven by cost and environmental considerations, and enabled by significant advances in, and a growing variety of packaging and interconnect technologies, we are enjoying an ever-improving price/performance ratio.

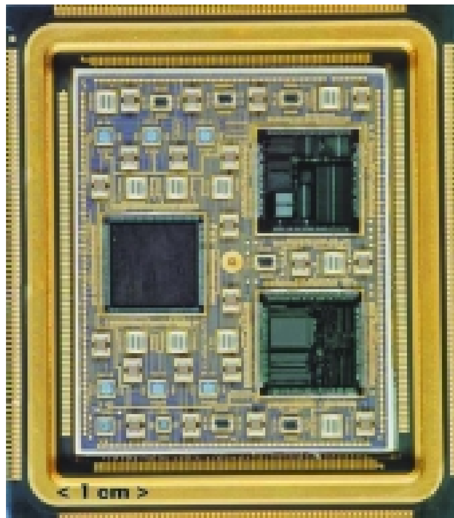


Figure 1. Example of an MCM-C in ceramic packaging: the SPARC computer in VFL technology (courtesy of Astrium Space)

On the other hand, space electronic hardware has not been changing so rapidly. However, the same drivers are also pushing the space community to face radical changes towards faster, smaller and cheaper solutions. Changes are happening in all areas, but it is generally recognised that interconnection and packaging are one of the major challenges when trying to reduce the volume and mass of spacecraft electronics whilst still improving performance, reliability and cost.

Major changes occurring in the area of electronic packaging and assembly technologies are having a profound impact on space components and systems, for example:

- the increased use of plastic encapsulation
- the miniaturisation of packages, e.g. Chip-Size Packages (CSP)
- the high pin-count required by complex digital ICs and provided for by, for example, PGAs (Pin Grid Arrays), BGAs (Ball Grid Arrays), etc.
- the proliferation of Multi-Chip Modules (MCMs) and the introduction of chip-stacking concepts.

In order to address these issues, the Component Technology Board (CTB) has established a Working Group on Hybrids, MCMs, Interconnections and Packaging, which set itself as an objective the establishment of a set of prioritised recommendations for actions to be taken. The strategic analysis performed by the CTB WG was based on the following concerns:

- availability of materials and processes for European users (without the unacceptable risk of embargos)
- access to sources with competitive prices and delivery times
- follow-on of technology evolutions, in order to anticipate all of the consequences for system and equipment design, manufacturing, inspection and testing
- re-use of technologies developed in other industrial sectors.

Analysis and expected evolution
Needs and trends were analysed, specifically from Eurospace inputs, in terms of space-mission performance requirements driven by key materials and technologies. The WG decided to limit its efforts to Level-1 (interconnections between chips) and Level-2 (interconnections between modules) of the four possible levels of interconnection.

For Level-1, we have SCMs (Single-Chip Modules), Hybrids, and MCMs (Multi-Chip Modules), and the WG identified the following areas of technology evolution:

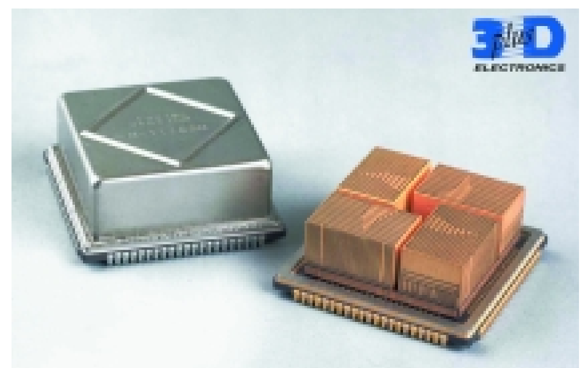


Figure 2. Example of MCM-V: the 640 Mb memory module for the Solid-State Recorder of the Cluster-II spacecraft (courtesy of 3DPlus Electronics)

– Chip attachment: new adhesive materials and larger chips, up to and beyond 20 mm side dimensions.
– Wire bonding: increasing number of pads (500 and more) and decreasing pitch and wire diameter.
– CSPs (Chip-Scale Packages): new package technologies able to reduce the area occupied by the package down to the chip area.
– Use of plastic encapsulation (in addition to hermetic encapsulation) for space applications and microwaves.
– Increasing utilisation of chip-stacking technologies in MCM-V (Vertical), in addition to traditional MCM-C (Ceramic), MCM-D (Dielectric) and MCM-S (Silicon) technologies, which will be very much improved in the direction of VFL (Very Fine Lines) and increased numbers of layers.
– Utilisation of LTCCs (Low-Temperature Co-firing Ceramics) for space and microwave applications.

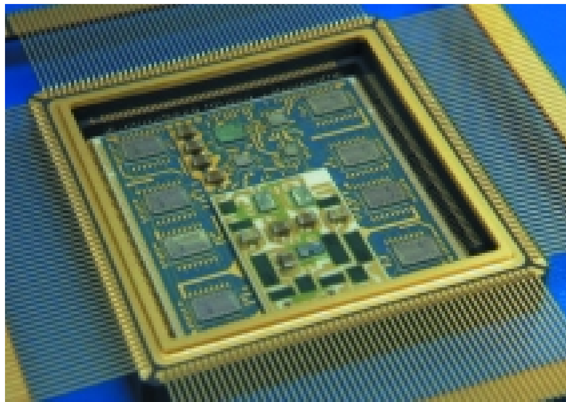


Figure 3. Another example of MCM-C in a 220 I/O ceramic package (courtesy of Alcatel ETCA)

Recommendations
In order to maintain and improve on the achievements of European space industry thus far, and to be aware at all times of the state of the art in hybrids, interconnections and packaging, the WG proposed the following strategic recommendations.

Recommendation 1: Invest in the approval of manufacturers (merchant and captive) and extend their capability domain
In the past twenty years, a number of European hybrid manufacturers have been approved by ESA. The great majority of them are ‘captive’, in that they produce hybrids for use in their own equipment but do not sell them on the open market. The WG recommends maintaining and even increasing that competitive European capability by approving new manufacturers - both captive and merchant (i.e. selling on the open market) - and promoting advances by supporting the evaluation of new hybrid technologies when these are proposed by European manufacturers active in the space field.

Recommendation 2: Establish specialised micro-packaging services
It is anticipated that space-system manufacturers will need specialised services for the production and assembly of semi-finished parts. It is therefore recommended to establish suitable small- and medium-size companies in Europe able to provide such specialised services, for example for the provision of:

– custom interconnect substrates (e.g. special materials, such as aluminium nitride, direct-bond copper) and special conductor systems (copper, multi-layer, etc.)
– special chip-assembly methods (e.g. flip chip, BGA, fine pitch automatic wire bonding)
– specialised hermetic sealing methods (e.g. laser welding, ion-beam welding)
– non-hermetic sealing, ruggedisation or radiation shielding of SCMs and MCMs.

Recommendation 3: Perform R&D activities in the field of micro-packaging technologies (Level-1 interconnections)
Building on existing and/or emerging technologies, specific R&D efforts should be undertaken to cater for compliance with space requirements. The list of activities includes, but is not limited to:

– very fine line interconnect (down to 75 micron) substrates: MCM-C, MCM-L
– chip-stacking technologies: MCM-V
– KGD (Known Good Die), CSP, COB (Chip on Board)
– investigation and evaluation of new and improved chip-attach adhesives
– flip chip and underfill
– micro-packaging technologies for MEMs
– advanced material hybrid packages: AlSiC, AlBe, AlN
– non-hermetic encapsulation.

Recommendation 4: Encourage the design/availability of standard hybrid products for space applications
There is a significant and growing market in standard hybrid products for space applications that is currently not being addressed by European hybrid manufacturers. The goal is to encourage ‘open market’ hybrid suppliers in Europe to address the needs of space applications for standard hybrid products such as: on-board processor modules, bus couplers, DC/DC converters, etc.

Recommendation 5: Perform R&D activities in the field of SMT, advanced PCBs and related technologies

The objective here is to evaluate Surface Mount Technology (SMT) for new devices like LGAs (Land Grid Arrays), BGAs (Ball Grid Arrays) and CGAs (Column Grid Arrays) on advanced PCBs (Microvias, high-thermal-performance core), including the board itself. Furthermore, new stacking technologies (3D) exploiting Fuzz Buttons, Interposers, Gold Dot and Conductive Elastomeric Contacts should be evaluated for space application.

Recommendation 6: Perform R&D activities in the field of microwave and optical interconnection and micro-packaging

One objective here is to address the interconnection and packaging needs for electronic hardware handling RF and microwave signals. A second objective is to develop optical interconnection solutions for the transport of digital or analogue signals.

On-going CTB WG activities

The above Recommendations have resulted in a detailed action plan to be implemented over a five-year period, starting in 2000. The funding for these activities is being contributed by ESA (TRP and GSTP), national space agencies, and industrial partners active in the field.

The activities being undertaken as per the first quarter of 2001 are as follows:

– Evaluation of two high-density interconnect technologies: Fodel on LTCC and thin-film multi-layers.
– Evaluation and approval of VFL (Very Fine Line) and embedded-capacitor MCM-C technology.
– Evaluation and approval of 3D stacking technology (MCM-V).
– Development and pre-evaluation of CSP (Chip-Scale Package) stacking techniques.
– Investigation of CSPs for space applications.
– Evaluation of the use of advanced materials (SiC) for power hybrid packages.
– Development of an advanced test chip (strain gauges and sensors).
– Development and pre-evaluation of DC/DC converters using 3D stacking technology.
– Validation of ceramic BGA packages and their assembly.
– Non-hermetic-encapsulation testing.
– Evaluation of flip-chip mounting, and assessment of reliability enhancement by the use of underfill.
– DSP MCM design validation.
– High-density interposer evaluation.

Meetings of the WG are taking place at regular intervals, with progress being reported both to the members and to the CTB itself.

The ESCC and ESCIES Web Sites

ESCIES has already been presented in the pages of the first two issues of Eurocomp. From the outset it was foreseen that there would be a need for a second web site to support the ‘Components Coordination’ activity more generally. Without a collective name, at the time the domain name ‘escies.org’ was registered, a generic name ‘spacecomponents.org’ was also registered. This name is presently being used for the European Space Components Coordination (ESCC) web site. Both the ESCIES and ESCC web sites are hosted on a common server located at ESTEC. The sites are linked together in their ‘public’ areas, but both sites also have ‘private’ areas. A common Directory Server handles user access, and only one user ID and password are needed to access both sites. What a registered user can actually access depends on which groups he/she belongs to. The ESCC web site supports the active work of the various bodies (SCSB, CTB, PSWG, etc.) and ad hoc working groups, and this is the basis for a particular area being open to just the members of that group.

So what is the purpose of two web sites? It is primarily to separate factual component data from the publicity and developmental work. The former is in ESCIES and the latter in ESCC. Of course, the ESCC activities lead to the release of data, specifications, component evaluation and qualification results etc. and these ‘products’ will appear in ESCIES. ESCIES is itself an ESCC product. Deliberations on how ESCIES should develop may well appear in the ‘private’ area of ESCC within the PSWG section, but the outcome of decisions would be seen in ESCIES itself.

Another feature of the ESCC web site is an online document review process. A document is posted for review, for example a draft of an ECSS Standard for ASICs. Members of the ASIC WG can read the draft, post one or more comments using an online form, and then read (using a standard browser) all of the other posted comments. These comments can be sorted by subject field, which typically contains the paragraph number - so that all comments on a

The outline site maps for ESCIES and ESCC

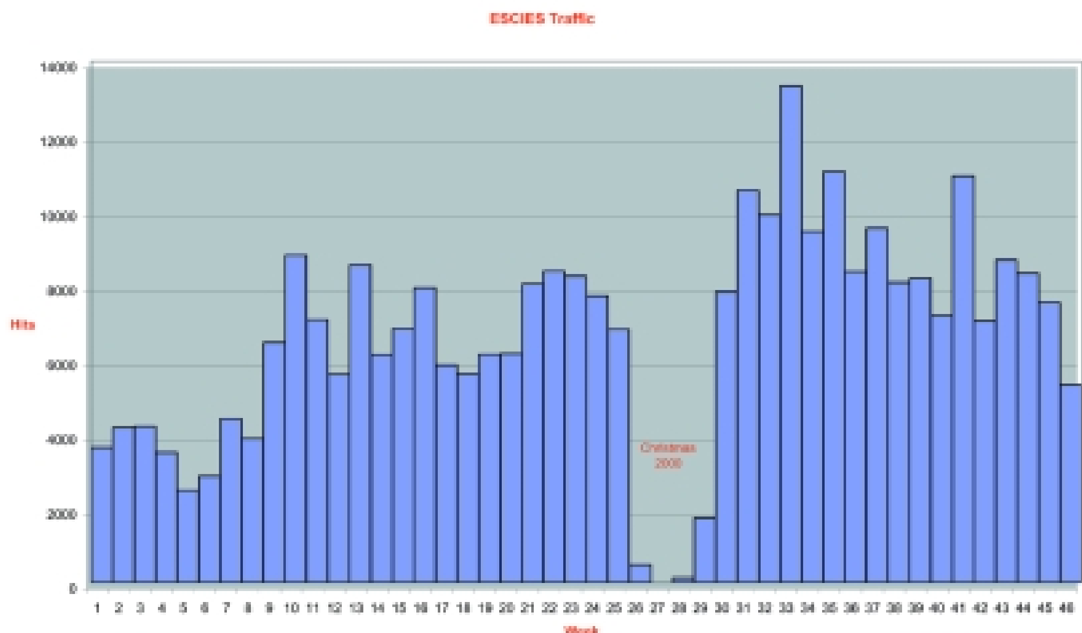
particular paragraph appear sequentially. The WG secretary can then extract the posted comments to prepare a consolidated view or for discussion at a WG meeting.

The interactions between ESCIES and ESCC are illustrated in the accompanying figure.

Turning to ESCIES, which has now been running for close to a year, there is a steady increase in utilisation (see illustration) and a gradually increasing body of registered users.

Data from sources other than ESA is still very limited. A first meeting to discuss data contribution was held, at Eurospace's request, at ESTEC on the 5 April 2001. The results are available in the 'private' section of ESCIES and are expected to lead to the gradual availability of data from manufacturers and users. Development work on ESCIES continues with efforts to improve the search engine, and in particular the meta-data. The ESCC web site too will continue to be expanded and information will be rationalised between the two sites. Existing users are encouraged to contribute to the online discussion groups and for those individuals and organisations who have not signed up to ESCIES, we encourage you to connect to:
https://escies.org
and also to look at:
https://spacecomponents.org

The ESCIES and ESCC web sites are developed and supported under an ESA contract with OLaoghaire Industries.



EEE Reliability Prediction:
Creation of a New Working Group

For the last 25 to 30 years, MIL-HDBK-217 has remained the accepted worldwide failure-rate standard. However, because this document has not been updated for several years and is no longer supported by the US Government since Perry's initiative, European industry considers it vital to explore the possible future means of modelling and calculating the reliability of (electronic) space equipment and systems.

Already in 1999, Eurospace initiated a working group on this matter and it was decided to organise two major events:
– a *European Reliability Meeting* (9-10 June 1999, ESTEC, Noordwijk): this was attended by approximately 30 people (representing telecommunications, aerospace, etc.) and was considered as preparation for the International Workshop
– an *International Workshop* (20 March 2000, ESTEC, Noordwijk) during the ESA ESCCON 2000 conference: this was attended by about 120 people (mainly from space industry).

Based on these events, in early 2001 the SCSB initiated an enlarged working group, with members drawn from space industry and other space agencies. Its activities are focussing on the three main outcomes of the International Workshop, in order to:

(i) address the suitability of RAC PRISM and CNET RDF data and tools for space needs as a replacement for the obsolete MIL-HDBK-217. The WG will elaborate ways of using one of these tools (or a combination of them) for space applications

(ii) address the maintenance of the databases at the same time; this will include investigation of a potential European space-industry contribution to the RDF database and/or an international contribution to the RAC database (e.g. data-sharing consortium)

(iii) propose the standardisation of a reliability-assessment methodology, including failure-rate estimating based on test/manufacturer data and other engineering methods and approaches (e.g. FMEA, fault tree, de-rating analysis etc.). This will include consideration of an acceptable 'Physics of Failure' approach, as well as the investigation of some existing documents (e.g. SSB EIA Engineering Bulletins).

The working group's findings regarding points (I) and (ii) are intended to be submitted as proposals for two different standards (e.g. methodology guide, failure-rate estimation procedure) to be formally released subsequently by the ECSS. For point (ii), the working group's proposals will only be established as recommendations. In particular, successful or unsuccessful experiences in the field of data(base) sharing and/or maintenance will be analysed in order to propose an effective way of overcoming the known problems. However, the formation of a data-sharing consortium (at either European or international level) is not within the scope of the working group.

Several companies (Alcatel Space Industries, Alenia Spazio, Astrium GmbH and SAS, ATMEL) and space agencies (CNES, ESA) have delegated reliability engineering experts or EEE part/ technology experts to form this working group, which will receive formal ECSS delegation (through the ESCC) to perform the above-mentioned activities. This working group reports to and receives policy directives from the PSWG chairman (F. Linder/CNES).

Also, some collaborations are being initiated with non-European agencies (e.g. NASDA, NASA) and companies in order to enlarge the working group's 'field of view', which is considered essential to match international developments in the reliability field. It is interesting to note that similar parallel investigations are currently being conducted in the USA and Japan by agencies and/or delegated working groups. Exchanges with these ongoing activities in the USA are Japan are therefore being encouraged. The working group's terms of reference allow new members to be invited to make specific contributions, for example in terms of methodology support, data or information exchange, etc.

Following the initial kick-off meeting held on 28 February at ESTEC, the first technical meeting took place, again at ESTEC, on 18 April, with a NASDA-delegated representative present. The next meeting is scheduled for June at CNES, Toulouse (France), with the objective of assessing and testing the RAC PRISM and CNET RDF data and tools.

All requests for information about, or proposals for collaboration in the ongoing activities are welcome.

On behalf of the working group:
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The European Preferred Parts List (EPPL)

After one and a half years of existence, the EPPL and its infrastructure are becoming well-established and well-positioned to serve as a basic vehicle for parts standardisation within the space community. The objective of any PPL is to allow users to direct their projects towards a limited number of components, values, tolerances, and so on, thereby increasing the volume of procured components while at the same time fulfilling most design application needs. It becomes ever more pertinent nowadays as the high-reliability market for components consolidates, with the reduction in military applications.

It may be informative to differentiate here between a PPL and a Qualified Parts List (QPL). A QPL typically catalogues, for each qualified component, the most extensive range within a qualified domain. From this list, a PPL will extract what currently are the most commonly used components and perform a standardisation and type-reduction exercise. A PPL will also include components that have not been fully qualified, but only evaluated, either fully or partially for an application, and used in a space project. This is the most important part of a PPL. Qualified and fully evaluated components are listed in Part I of the EPPL, whilst partially evaluated components are listed in Part II.

The full value of a Part II EPPL is realised when it is used as a means to share usage data amongst projects. Data is the key to entering EPPL Part II. The user of a Part II component may only need to perform incremental testing with respect to tests already performed by an earlier user, or at best no additional testing at all. In such a case, the effort to evaluate a new manufacturer/component is significantly reduced. In addition, the prices and delivery times for the component itself may fall in the medium term as manufacturers build to cater to usage patterns.

In order to meet this goal, the EPPL is designed as a dynamic vehicle, i.e. it is updated frequently. In addition, it is designed to be inclusive, in that the entire space community can participate in this updating. Here's how:

- European Space Industry runs tests to verify the suitability of components for space applications. Therefore, *propose an entry !*
- Component Manufacturers holding a CECC qualification may wish to promote their components for space use. Therefore, *propose an entry !*
- Parts Procurement Agencies run evaluation programmes and Destructive Physical Analyses on components for their customers and this is valuable data for the EPPL. Therefore, *propose an entry !*

Whenever a new component or a new European source is used and an evaluation of the component and its manufacturer is performed, this information can be shared by filling in an Entry Application Form (EAF), and sending it with a copy of the corresponding data to the EPPL Manager.

The EAF may be found at:

http://www.escies.org/public/eppl/

as well as the address of the EPPL Manager.

In conclusion, the full benefits of the EPPL will be achieved only when both its basic and its dynamic features are exploited. Project Managers can benefit by using the European Preferred Parts List in their programmes. Component users and manufacturers can benefit from the wide availability of component data.

De-Rating and Worst-Case Analysis

The Component Technology Board (CTB) has identified in its programme the need for a De-rating and Worst-Case Analysis standard for Electronic, Electrical and Electromechanical (EEE) components. De-rating is a tool applied during the design process to increase the useful lifetime of EEE components. A balance must be achieved in practice, as overly conservative de-rating values can lead to the unnecessary oversizing of components, and hence excessive component cost, equipment weight, and launch mass.

The new ECSS Standard, much like the EPPL, will consist of two parts: a Standard document proper,

and on the ESCIES web site figures for load ratios and end-of-life drifts. In addition, components that are affected by radiation will be flagged.

As you may have noticed in the previous sentence, proposals are being made to change the terminology in order to avoid confusion:

– Using ‘load ratios’ instead of ‘de-rating’, which describes the action. ‘Ratio’ has been used instead of ‘factor’ to keep the percentage value and avoid further confusion.
– Use of ‘end-of-life drifts’ instead of WCA values, as EOL drift is one of the elements used in worst-case analysis.

We are working on the presentation of these figures, which will consist of separate tables, de-rating, worst-case analysis and application notes.

The technical content of the new Standard has been justified, both theoretically and practically, by exploiting test results in order to show how parameters change and how the relevant factors evolve. A link to the rationale used in defining the figures will also be provided.

The part of the Standard comprising the Introduction and Definitions is ready to be submitted for review and acceptance by the appropriate bodies.

The work for the figures has been divided into approximately 20 families. We expect completion for issue towards the end of this year.

ESCCON 2002:
European Space Components Conference

ESCCON 2002, the European Space Components Conference, will be held during the week of 23 to 27 September 2002 in Toulouse, southwest France.

Formerly known as the ESA Components Conference, ESCCON is sponsored by the Space Components Steering Board (SCSB) and its members. The Conference continues to be held every two years and serves as a forum for the exchange of information and ideas concerning global technology developments and specifically issues relating to space components.

ESCCON 2002 is being organised by the Centre National d’Etudes Spatiales (CNES).

Look out for the Conference First Announcement this September !

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