AVIONIC SYSTEMS STANDARDISATION COMMITTEE

ASSC ARCHITECTURE WORKING GROUP

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THE USE OF ARCHITECTURE REFERENCE MODELS FOR ARCHITECTURE EVALUATION*

0. EXECUTIVE SUMMARY

One of the activities of the ASSC Architecture Working Group is to consider methods for the assessment of candidate avionic architectures. The Working Group has considered the use of an architecture reference model as a basis for assessing architecture options and standards.

This document covers the nature of architecture refence models, lists the relevant models available, discusses how models might be used and identifies potential limitations of models. Little practical work has been carried out with such models to date, and this document does not cite any examples.

It concludes that there are good reasons to use a reference model for checking that an architecture specification includes all the major interfaces and that the interfaces are consistent. A reference model can only be used as one of one of many tools for architecture and standard evaluation, however. Recommendations for further work in order to develop or adapt a model that is most suited to the evaluation process are included.

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Figures and tables

1. INTRODUCTION

The ASSC Architecture Working Group was established to address system architecture issues relating to future avionic system technology and standards. The activities of the Working Group include the assessment of candidate architectures and supporting standards for applicability to the avionic environment. The Working Group has considered the use of an architecture reference model as a basis for assessing architecture options and standards.

This document has been produced by the Architecture WG to discuss the use of architecture models for assessment and evaluation. It considers:-

i) The nature of architecture reference models.

ii) Available models.

iii) How models might be used in the process of architecture and standard assessment and the potential limitations of reference models.

The documents concludes with recommendations concerning the use of architecture reference models by the Architecture WG.

2. ARCHITECTURE REFERENCE MODELS

The term model is used in engineering to describe a wide range of “non-physical” representations. In the avionic system context, for example, models are frequently produced that represent the dynamic behaviour of systems and the effects of failures on the data flow between system elements. The type of model discussed in this document, the architecture reference model, is somewhat different in nature and can be broadly defined as a representation of:-

a) The scope of an architecture (what it includes and excludes).

b) The constituent elements of an architecture.

c) How the elements interact.

It is this type of model that is most relevant to the activities of the Architecture WG. Models of dynamic behaviour, data flow and other detailed aspects of system behaviour and configuration and more relevant to system engineers engaged in the design and development of complex avionic systems.

It is not easy to define what an architecture reference model should contain. This is, in part, due to a general uncertainty as to what the term architecture actually means in a avionic system context. Opinions on this subject vary, as these two definitions supplied by members of the Working Group show:-

i) STANAG 3908 - "In avionics (an architecture is) a representation of the hardware and software components of a system and their interelationships, considered from the viewpoint of the whole system".

ii) ASAAC - "The set of common elements, modules (hardware and software); interconnections and construction rules that are required which, when combined together with non-common sensor front-ends, effectors, interfaces, displays and controls, application software etc can be used to construct any avionic system to give the required qualities of lower LCC, interoperability, etc".

It is necessary for the Architecture Working Group to be flexible in its view of the nature of an avionic system architecture so as not to restrict its activities unduly and be of maximum use to its members and "customers". In this document, therefore, a number of reference models are considered that may not be compatible with some definitions of architecture and cover only some relevant parts or aspects.

3. AVAILABLE MODELS

There are some architecture models already in existence and there are, in addition, some architecture or communication system descriptions that effectively define all, or part of a model. The SAE AS-2A-1 Real-Time Model Task Group have attempted to collate the information available on communication and system models. The following is a summary of the information from their document AIR 4885, describing the nature, content and limitations of some of the available models.

a) The OSI Reference Model

The OSI Reference Model is shown in Figure 1. Its origins were in the communication of data over telephone lines and colour the structure of the Model. For example, the Physical Layer was concerned with signalling the data; the Data Link Layer with providing a reliable logic point-to-point link; the Network Layer with routing through the meshed network etc.

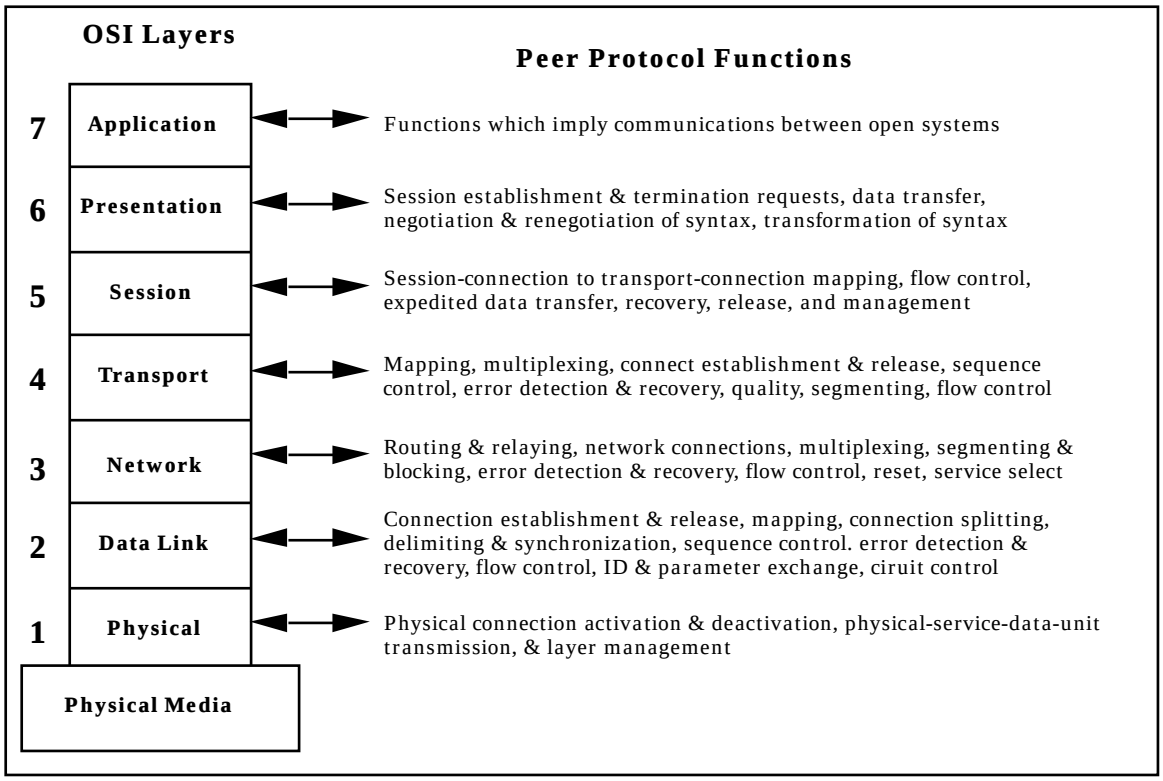

Figure 1 The OSI Reference Model

b) <u>The RTMT Model</u>

The RTMT model is shown in Figure 2. In this, the User Application of the data communication service interfaces to the Real-Time Communications Protocols (RTCP), which have embedded within them the physical networks which transfer the data, such as the SAE standards AS4074, AS4075 and AS4942. Thus, there is only a single interface defined such that the implementation of the RTCP and network protocols may be made as efficient as possible.

Requirements for the RTCP are described in AIR 4886. The Data Communication, Synchronisation and Management services intended to be provided by the RTCP are described in ARD50033.

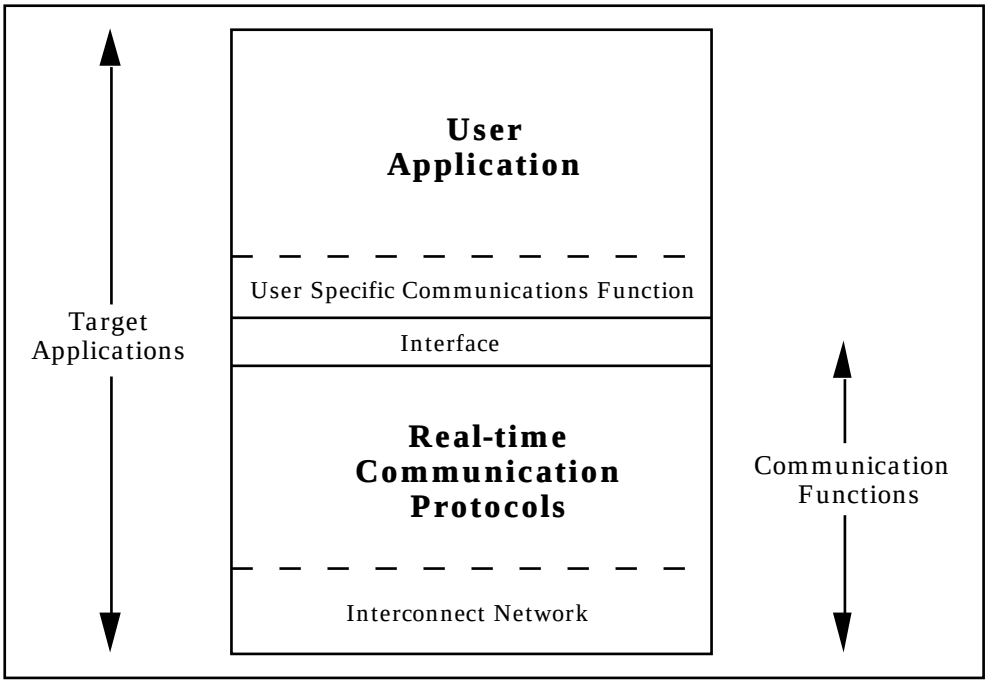

Figure 2 RTMT Model

c) POSIX

The IEEE 1003 committee in the USA is responsible for developing the Portable Operating System Interface Standard (POSIX) standard. The work of IEEE 1003 was undertaken primarily to promote application source code portability across hardware platforms with the aim of generating a standard interface between the application software and the hardware dependent aspects of the system. The model for this is shown in Figure 3. The application software would use calls to standardised procedures and the compiler/operating system would translate these procedures into hardware dependent code. The initial focus of the activities was on UNIX based systems and although the POSIX standard is intended to be independent of the underlying operating system there is a direct relationship between many of the functions of POSIX and UNIX.

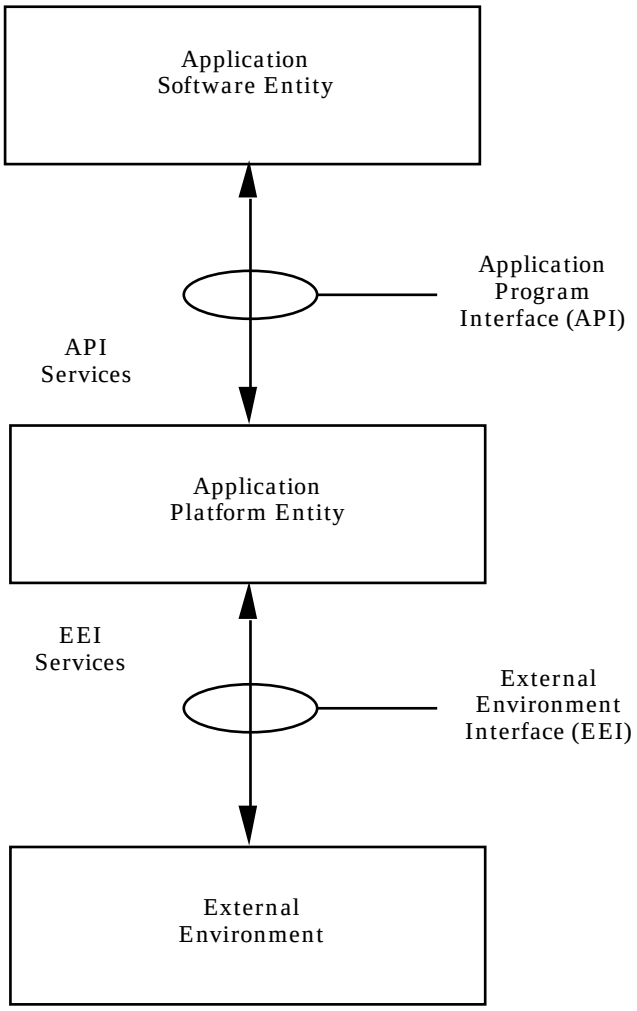

Figure 3 POSIX Model

d) NIST

National Institute of Standards and Technology. A general information system model.

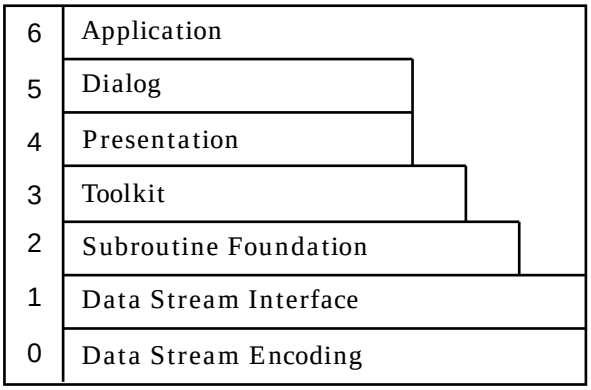

Figure 4 NIST Reference Model

e) DISA CIM

Figure 5 - Defence Information Systems Agency Corporate Information Management. A technical reference model for information management (?). Based on NIST and software focused. Business oriented - Client Server.

f) OSA

Figure 6 - Open Systems Architectures Working Group. Derived from DISA. Weapon and Warfare Support Services Technical Reference Model (WWSS TRM). Introduces hardware and real-time.

g) ARINC 651/653

Civil IMA. Complete system. Communications defined in the bottom three layers of Application/Executive/Hardware Interface System/Hardware. Two interfaces defined Application/Executive (APEX, ARINC 653) and Core hardware and Hardware Interface System (HIS) Executive (COEX).

h) SGOAA

Space Generic Open Avionics Architecture. NASA developed to allow changes in hardware without needing to re-certificate software. Covers complete system. Weak on communications? Only identifies logical and direct.

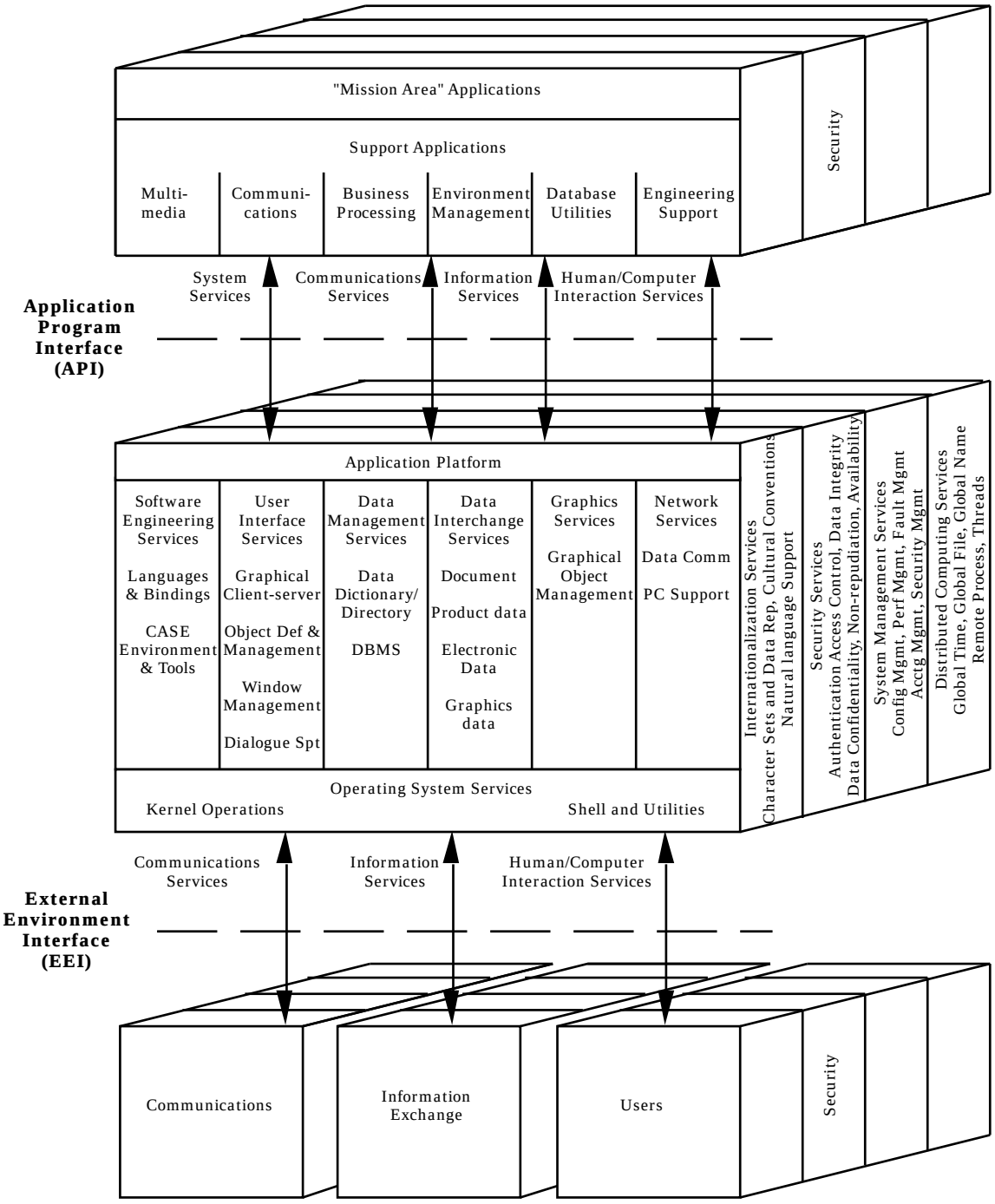

Figure 5 DISA CIM (TAFIM Technical Reference Model)

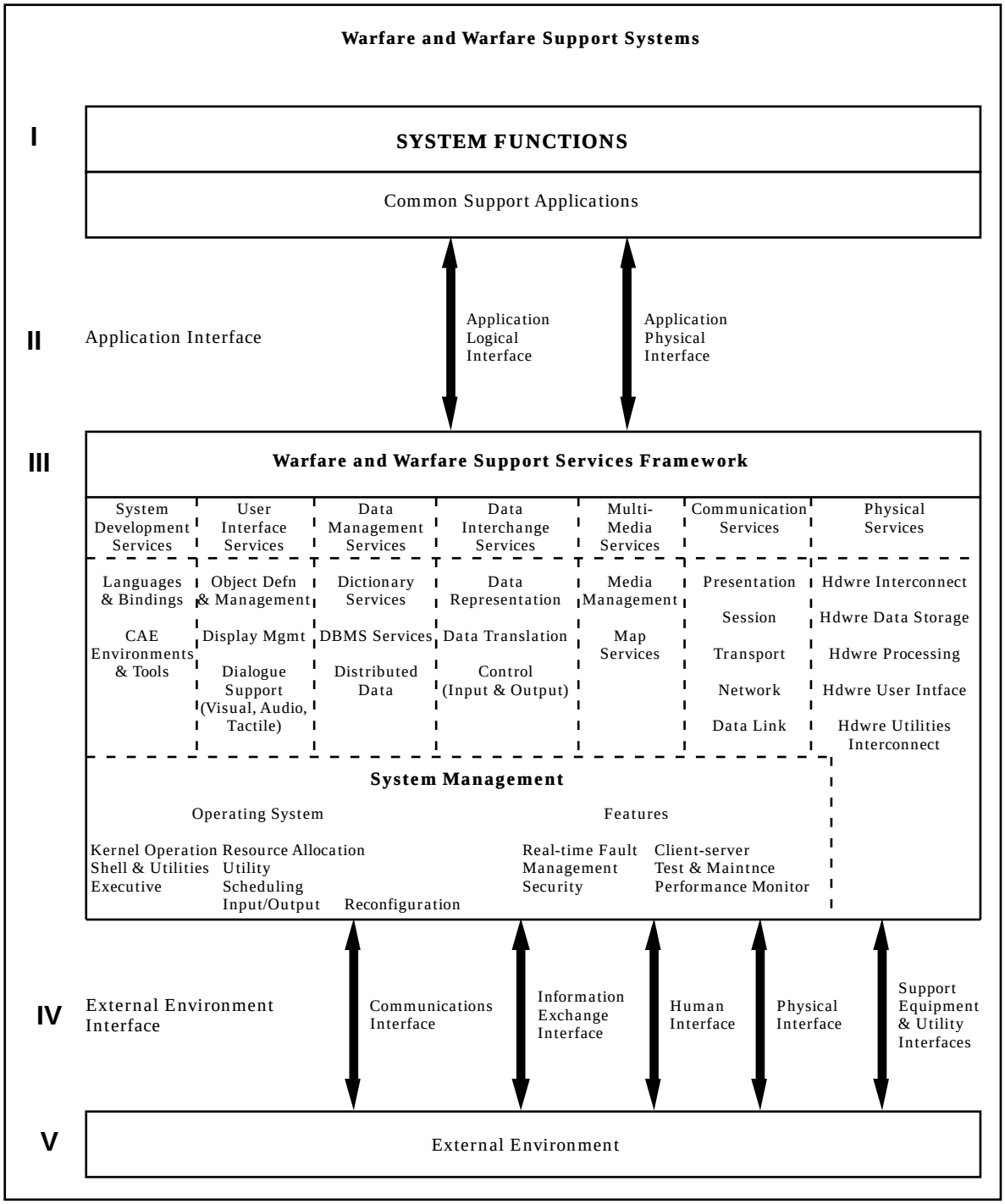

Figure 6 WWSS Technical Reference Model

i) GOA

Generic Open Architecture. Derived from SGOAA by SAE AS-5. Addresses communications less. Under development. Complete system. Intended to classify interfaces to transition open standards to military avionics.

g) GAM-T-103

Communications model with four layers: User/Transfer/Link/Physical. Derived from OSI. Real-time orientated. Set of standards defining interface to User and then how to implement for specific network. Not all transfer services offered for all networks.

4. USE OF REFERENCE MODELS

The Architecture Working Group needs to assess and evaluate open architectures and supporting standards for use in avionic systems. Important aspects of this work include the need to check for completeness and consistency. For example, does a proposed architecture or standard define all of the important interfaces? Are all of the defined aspects consistent or is there ambiguity in the definitions?

A reference model which defines the major elements of an open architecture and their interfaces would provide a framework to check coverage and consistency. The candidate architecture could be mapped onto the reference model, with this mapping process highlighting areas of ambiguity and lack of coverage. The Architecture Working Group have examined the possible use of reference models. Figure 7 shows a high level mapping of the ARINC IMA architecture onto the SGOAA model, showing which interfaces are defined in the IMA description. If a comprehensive reference model could be defined, it would be a powerful tool for this type of coverage and consistency checking. Having identified any gaps and ambiguities, it would then be possible to:-

a) Address gaps and ambiguities by modifications and/or additions to the candidate architecture or standard.

b) Use other available definitions or standards to plug gaps, producing a composite set of complementary definitions and standards.

A good reference model would also provide a framework for the assessment of candidate architectures or standards using metrics. The advantages of using metrics for assessment have been considered by the Architecture Working Group and are addressed in a separate discussion paper.

It should be emphasised, however, that a reference model would probably only be able to address a limited range of architecture properties. As noted in section 2, the definition of the term architecture in the avionic system context is debatable. It is likely, however, that any open architecture or supporting standard under consideration for future avionic system application would have a number of important properties that would be difficult to include in a reference model, such as the GOAA model. These include:-

- reconfigurability
- human/machine interfaces
- implementation aspects such as modularity
- updateability

5. RECOMMENDATIONS FOR THE USE OF ARCHITECTURE REFERENCE MODELS BY THE ARCHITECTURE WORKING GROUP

The advantages of using a reference model for completeness and consistency checking and as a framework for evaluation using metrics provide good reasons for the Architecture WG to use models in support of future activities. The limitations outlines in the previous section, however, must be noted and any reference model can only be used as one of many tools for architecture and standard evaluation.

The activities of the Architecture WG in the future will be mainly concerned with reviewing the applicability of emerging open avionic architectures and supporting standards to UK avionic system applications. The two most important emerging architecture/standards that will need to be reviewed are:-

i) Architectures and standards emerging from the ASAAC Programme.

ii) Civil IMA standards (ARINC 650 series).

In addition, architectures/standards emerging from US military R&D programmes (such as JSF/JAST) may also be important.

It is recommended that the Architecture WG seeks to develop or adapt a model that is most suited to this review process. It is suggested that this model should be generic and independent of the architectures, standards and programmes noted above so that the review process can provide an independent cross-check of aspects such as completeness. Of the models described in Section 3, the SGOAA/GOA model seems most appropriate, although

the future direction of its development is unclear. It is therefore recommended that the Architecture WG consider the adaption of the SGOAA/GOA model to suit its objectives. It is proposed that:-

i) The SGOAA/GOA model is mapped onto an existing system architecture to highlight general strengths and weaknesses.

ii) The currently available IMA and ASAAC architecture definitions are mapped onto the SGOAA/GOA model to highlight strengths and weaknesses specific to open architectures and standards.

iii) The lessons learned from i) and ii) above are used by the Architecture WG to:-

- influence the development of the model by the SAE
- develop enhancements to the model as appropriate
- develop guidelines for the use of models for architecture/standards development and assessment.

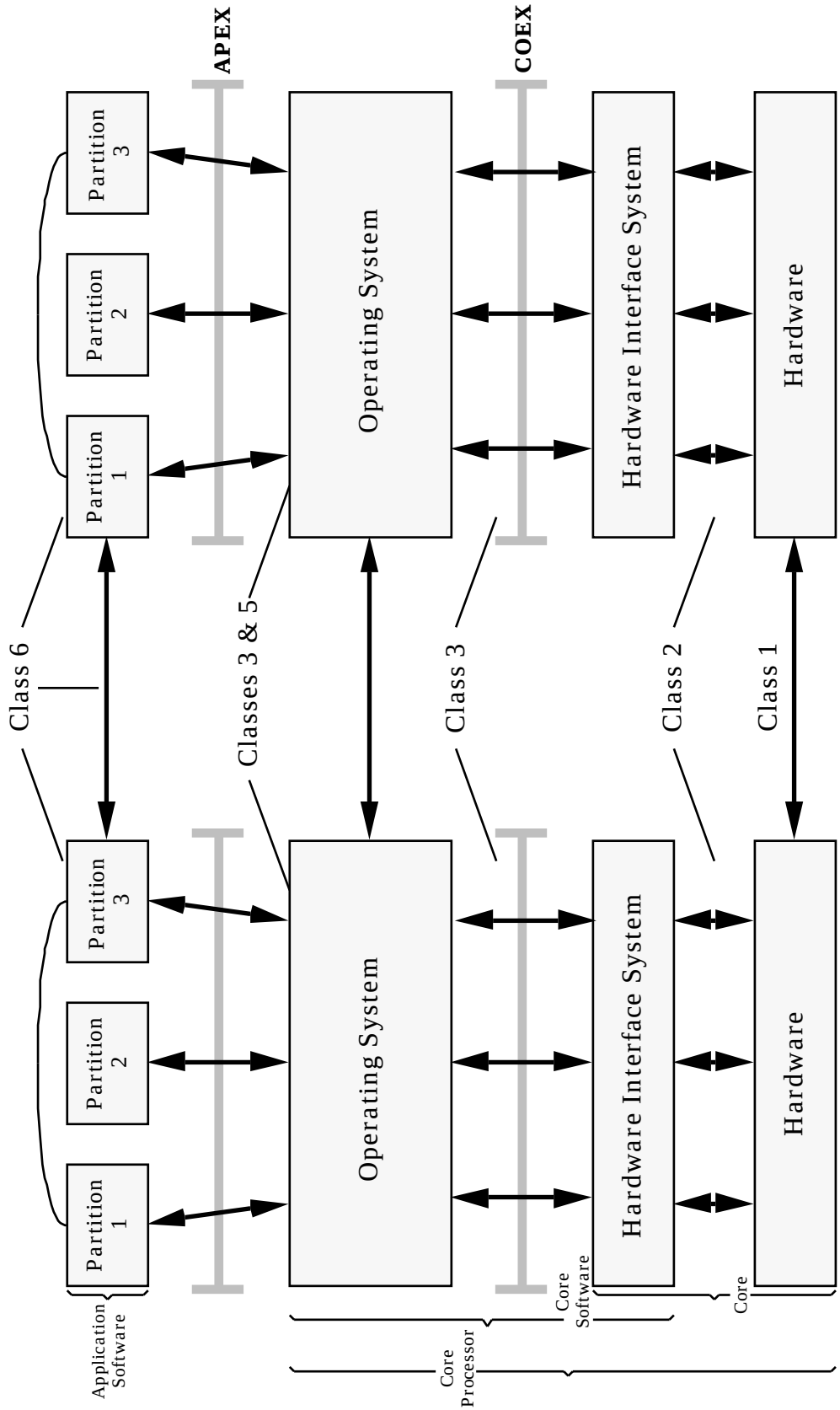

Figure 7 Mapping of GOAA Classes onto ARINC IMA Architecture