AV/ICT standards & compliance engineering framework

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Author Note:

This paper contains the author's own opinions only

Abstract

This document examines and describes the elements of the organizational and technical regulatory frameworks within which a standards and compliance engineer typically operates for audio-visual (A/V) equipment, multimedia equipment, and information and communication technology (ICT) equipment.

Keywords: ICT; A/V; compliance engineering; Information and Communications Technology Equipment; Standards; Technical regulations; Organization; Audio-visual; Multimedia

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Table of Contents

Abstract 2
Disclaimer 2
About the author 2
AV/ICT standards & compliance engineering framework 6
Top level framework 6
Framework subsystem functions 8
Development 8
Specifications and standards 10
Compliance 13
Standards development organisations 17
Other equipment manufacturers (OEMs) 20
Packaging and documentation 21
Legal 21
General 21
Government 23
Regulators 24
Regulations 26
Reporting 27
Contracts 28
Exemptions 28
Metrology (measurement standards) 29
Marketing and Sales 30

General 30

Products 32

Delivery methods 34

Customers 35

Competitors and business partners 37

Environment 38

General 38

Protection of the natural environment 39

Business operations 40

Product energy use and efficiency 41

Chemical substances 42

Materials 42

Consumable materials 43

Post-consumer issues 43

Environmental operating conditions 45

Corporation 46

Manufacturing 50

Industry groups 51

Intra-company coordination 52

Conclusions 53

Abbreviations list 54

References 56

Table 1- List of abbreviations 54

Figure 1- Compliance engineering ecosystem overview 7

Figure 2- Development relationships 9

Figure 3- Product technical standards and specifications 10

Figure 4- Legal framework for AV/ICT compliance 22

Figure 5- Legal regulations 26

Figure 6- Marketing and sales functions related to compliance engineering 31

Figure 7- Compliance engineering relating to environment 40

Figure 8- Environmental operating conditions 46

Figure 9- Corporate structure and objectives issues for the engineer 47

Figure 10- Corporation structure 49

Figure 11- Manufacturing considerations 51

Figure 12- Industry groups standards and compliance role 52

Figure 13-Intra-company coordination 53

AV/ICT standards & compliance engineering framework

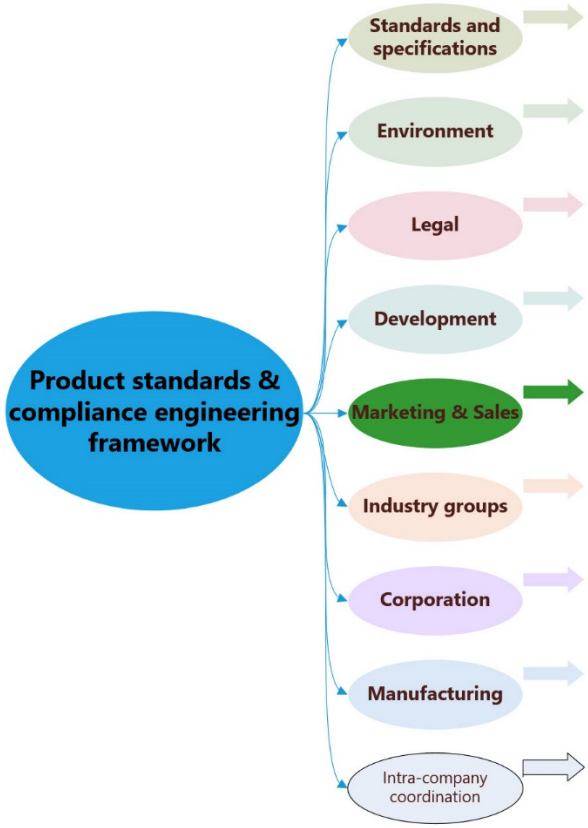
Product technical standards and compliance engineering for information and communications technology (ICT), audio/visual (A/V), and multimedia equipment are very complex systems that have far-reaching influence, extent and impact throughout the business environment in which it operates. Its role in product development is central to the success of not only a hardware product, but of software, services and the business operations itself. The roles not only affect product design and manufacture for functional reasons, but also many government technical regulations, business practices, and customer expectations depend upon and rely on compliance with parameters that products are expected and required to have. This doesn't happen without deliberate and structured engineering, commencing with the first concepts of a product and being integrated all the way through the development, testing, compliance certification and commissioning phases of the product, as well as use and end of service considerations.

This paper examines the organizational framework in which standards and compliance engineering may typically operate in a business, and attempts to show the interrelationships, reach and extent of its role in product development and business operations. Organizational models, structure, and roles may vary significantly from company to company, so this paper is not trying to specify any particular organizational structure. Rather, it's focusing on the functions that need to be done for product standards and compliance somewhere in or by an organization to bring products to market. These need not always be done by the one person or team, as multiple organizationally and geographically diverse teams may work in concert to achieve the desired outcomes.

Top level framework

Putting the standards engineer and the compliance engineer in the centre of the picture helps to show the perspectives of the role from this focal point. Figure 1 shows the broad categories of matters that engineers need to work with. Depending on the size of the organization, some engineers may specialize one or more in particular disciplines and less in others, however the full range of the elements in Figure 1 need to be accounted for in order to release products.

Figure 1- Compliance engineering ecosystem overview



The elements are very inter-dependent. Product development, legal, standards and specifications, takes the lion's share of the work of building, testing and certifying a product, but this is not done in a vacuum. The corporation decides on whether it wants the product in the first place, and whether the product is part of its core business objectives. The customers have needs and expectations that they wish to be fulfilled, but while thinking of those needs there are many things they rightfully assume will also be included, such as safety and non-interference with radio communications telecommunications networks and other equipment.

Manufacturing must build the product to the specifications and designs and samples produced by development, and in many cases, there are mandatory geographic regulatory compliance matters that must be dealt with for legal reasons. They must also build to budget, so the value proposition to the customer and the business is balanced and maximized. The core reasons for building a product usually involve bringing it to market, so it needs to meet market requirements and fulfil contemporary and relevant customer needs and be function and cost competitive, or customers won't buy it.

The preservation of the world's material and environmental resources and the reduction of waste to minimal and non-toxic levels are not only good business practices but are also required in many regulatory and business jurisdictions. In order to learn about the technical regulatory frameworks, and engender discussions with standards development organisations (SDOs), regulators and government, participation with industry groups is valuable to find out about impactful regulations and issues commonly faced by industry and to share learnings, general expertise and knowledge with the greater community of experts and practitioners.

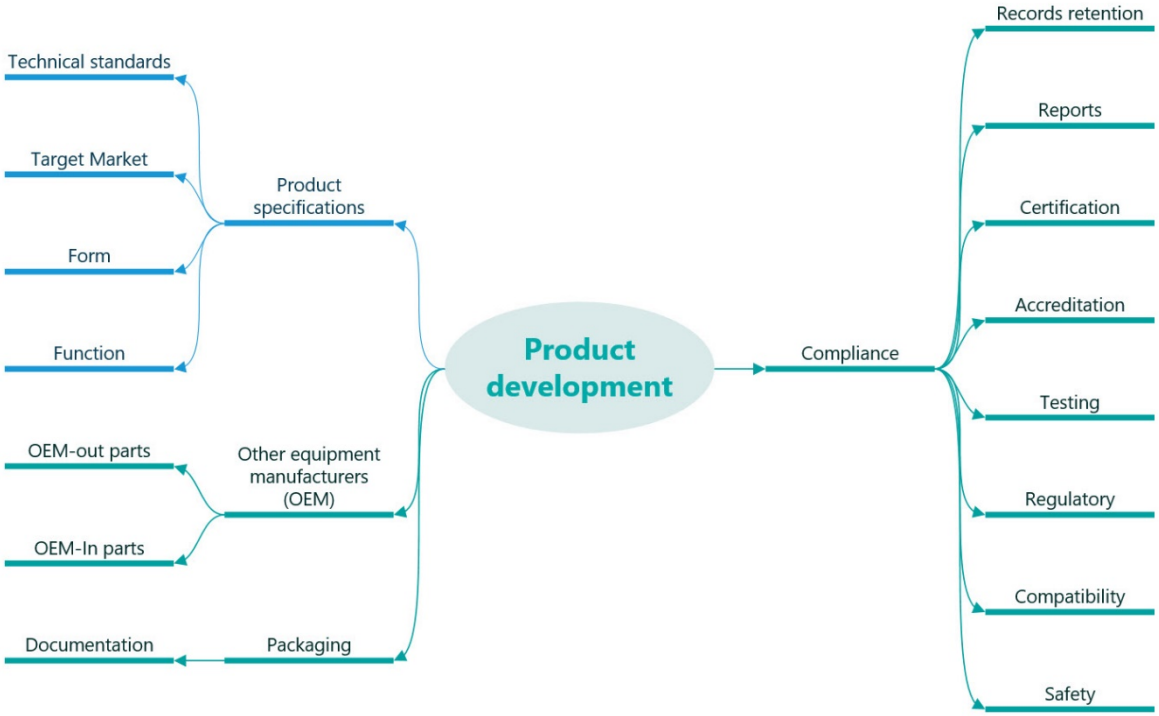
So, the standards and compliance engineers are a vital resource to the business and contributes a great deal to the viability and risk reduction of many products and services. The business should ensure that the role is adequately funded and supported by management, and resourced by qualified persons who are provided with appropriate succession planning to cover planned and unplanned leave, job rotation, and vacancies. In the following sections each of these elements will be examined in more detail to see how standards and compliance engineering relate to the business.

Framework subsystem functions

Development

Development teams are responsible for the design and function of the product. They're responsible for everything technical about the product, but they don't work in isolation from the rest of the business. This applies whether the product is a hardware product or a software product, or a cloud-service product or even business services. However, we will focus on hardware products for the purpose of this paper. Figure 2 shows the elements of the development process that typically the standards and compliance engineer interact with in the product development cycle.

Figure 2- Development relationships



It's vitally important to engage the standards and compliance engineer as early as possible in the development process so that essential technical regulatory compliance matters are incorporated right from the start. Adding in requirements after the product functionality has been finalized is very time-consuming and expensive as it may, and often does, require extensive reworking of the hardware to meet requirements which have little to do with the form and function of the product. For example, the product must be safe, not harm the operator or bystanders or public communications networks or interfere with licensed radio communications or harm the environment. And it must do what it's expected and advertised or claimed to do (fitness for purpose). The elements of the development process where compliance engineering impacts includes the following:

1. Product specifications and standards
2. Compliance
3. Standards development
4. Other equipment manufacturers (OEMs), and
5. Packaging and documentation

These items will be dealt with in more detail in the following sections.

Specifications and standards

According to ISO/IEC Guide 2, standardization aims to establish "*with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context*". It follows that standards documents define what the product (or service) must have or do or achieve to reliably meet common requirements and objectives as specified within the standards document. ISO/IEC Guide 2 indicates that the aim is to make the product fit for purpose in areas such as compatibility, interchangeability, variety control, safety, protection of the environment, and protection against product degradation under adverse conditions. Many thousands of technical standards documents exist ("standards" in this paper) covering many topics and are produced by many organisations. Recognised organisations dedicated to the production of standards are known as standards development organisations (SDOs).

Standards and specifications are always voluntary when published, until or unless they are specified as mandatory in some government regulation or required under a commercial contract.

Figure 3- Product technical standards and specifications

The technical standards for the products referred to in Figure 2 are shown in more detail in Figure 3. These determine the form and function of the product for the target market where the product is intended to be supplied. There are standards and specifications for all these matters.

Product specifications are developed by the product developer in consultation with marketing, customers, standards engineers and in consideration of the core objectives of the business. The specifications should include references to public standards to be used in the product as well as the functional requirements of the product itself, to streamline in a common way the satisfaction of common objectives mentioned earlier.

The standards engineer needs to work with development engineers when determining the specifications for the product to ensure all the standards product requirements appropriate and essential for the product have been accounted for in the product design. A relevant and agreed standards compliance list needs to be included in the specification of the product right at the start of the product's design. As a minimum this should include requirements for safety, electromagnetic compatibility, environmental protection (for example energy use and environmental toxicity), and where applicable include telecommunications and radiocommunications regulatory requirements as well. The standards can draw from many sources, such as public SDO standards, corporate standards, industry standards, and regulatory standards that are specified by government and their regulators. By their very nature, regulatory standards are non-optional, and can vary a lot in content and requirements between different regulators and geography. Very often it's the list of regulatory standards that may ultimately determine the countries where the product may be marketed, so it's important that the product developer and standards engineer have a good understanding of the target market.

Sometimes scope-creep happens, and the target market expands beyond the originally planned economies during or even after development. In these cases, the products for the newly added markets must be carefully analysed against the local requirements to ensure the products do not violate local laws and are properly certified where and as required. Not all designs are suitable for all markets.

Safety standards

ISO/IEC Guide 2 says safety is "*freedom from unacceptable risk of harm*", however there will usually be some residual risk[1] "*after risk reduction measures have been implemented*", so the aim of risk reduction is to reduce the residual risk to tolerable levels[2].

Safety standards are usually designed to be performance based, so they don't specify much about how to actually make a product. They determine whether the design chosen provides adequate safety that the community is entitled to expect. In fact, safety standards don't care whether the product works or fails, so long as it does so safely. Even where a product meets applicable safety standards, there may be other factors about the use and application of the equipment, known as functional safety (often required for systems, such as medical devices), which need to be analysed that's not covered in the equipment safety standard itself. Equipment needs to be safe not only for its intended use but also for reasonably foreseeable misuse.

Equipment safety standards, and many others, set minimum requirements only. Once those requirements have been met or bettered, the product can be certified as compliant. They are based on many decades of experience with products of the kind listed in the scope of the standard, and there are many standards, so the correct standard and parts of the standard need to be selected and applied to the product under evaluation.

Compatibility and interoperability

AV/ICT products usually are designed to work with other products, for example: exchange data, produce and amplify music, display moving or static images, communicate over wired and wireless networks, and draw energy from a power source of some kind. Standards and specifications exist to handle most, if not all, these situations. In some cases, proprietary specifications are used to fill a new or special need that hasn't been standardized

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[1] See ISO/IEC Guide 51 clause 3.8

[2] ISO/IEC Guide 51 clause 3.15 says tolerable risk is a "*level of risk which is accepted in a given context based on the current values of society*". The term is synonymous with "acceptable risk".

in public standards yet, or even just to differentiate a product from others on the market. Since standards are not generally mandatory unless legislation calls them up, it's fine for suppliers to use proprietary specifications that may even be confidential or unpublished or developed by themselves where there's not a mandatory standard that applies to that feature or aspect of the product. The supplier needs to consider the YOYO factor (you're on your own!) in these cases, where the risks of going it alone can be significant, as there might not be external expertise able to assist should problems arise in the design, if those products are not be able to properly interact with other standards-compliant products. So, caution is recommended when using a proprietary solution especially if a public standards-based feature could perform a similar function.

Another form of compatibility required is for products not to cause interference with neighbouring products, which might be the supplier's own products or other suppliers' products. Interference can be caused by unintended radio emissions or conducted disturbances which might cause mis-operation or failure of nearby equipment or loss of wireless communications or telecommunications services. Interference, and the complement of that – susceptibility, are well understood and standardized subjects that often have prescribed regulatory controls.

Compliance

Often known as conformity assessment, international standard ISO/IEC 17000 defines it as a "*demonstration that specified requirements relating to a product, process, system, person or body are fulfilled*". In other words, it's a formal evaluation of the product to ensure it meets its intended specifications; the product being the "*result of a process*" can be hardware, software, processed materials, or services.

Conformity assessment process

The conformity assessment process, or compliance engineering process as shown in Figure 2 on page 9, usually involves a qualified test laboratory inspection and testing of the product. The product is carefully measured against the assessible requirements in the product's technical specifications and standards, to produce a test report that lists how the product compares with all the evaluation criteria. When all the applicable evaluation criteria have been fulfilled and documented in the test report, the test laboratory can complete a

Declaration of Conformity (DoC) document, sometimes called a certificate of compliance, which is a statement or attestation that the product complies with all the essential stated objectives in the specification or standards for the product being assessed. Often the supplier's DoC (SDoC) also has a statement to the effect that all their products of the same kind also comply with the same requirements, as this can be required by regulatory authorities. If the product fails to meet any of the essential criteria this is a defect so the certificate of compliance od DoC cannot be completed. In case of a defect, corrective action such as an engineering change needs to be taken to bring the product into compliance and the product is then retested. This is not a good time to have a compliance failure, as remediation at this point can be very expensive and time-consuming to correct the defect.

Testing

The conformity assessment testing can be done in a range of ways, from informal to very formal. Usually conformity assessment testing is done on a type-testing basis. That is, only one or a few representative samples of equipment are tested. All the equipment of the same kind that is produced under an appropriate quality system must be reasonably identical with the type-test sample in so far as the matters dealt with on the DoC and compliance certificates are stated. Tolerance ranges of equipment components and manufacturing processes should be considered to ensure that the whole of production will not fall below the minimum parameters required in the standards. For this reason, some test laboratories and regulatory authorities require regular check testing of products from production, sometimes with regulatory oversight. In any case, manufacturing processes should include regular in-house production check testing of key parameters to ensure compliance is properly maintained over the whole production cycle.

Methods to check development progress against specific parts of the requirements up to in-house full conformance testing by the company's own development or compliance engineers may be done in-house. As some test facilities can cost millions of dollars, such as an anechoic test chamber for electromagnetic compatibility (EMC) testing, not every company is able to perform all in-house testing. Test facilities and expertise can be leased from third parties for the purpose of doing progressive check-testing if needed.

More formal testing methods involve the use of accredited test laboratories which can precisely measure using equipment calibrated against measurement standards to known

degrees of uncertainty. The issue with measurement uncertainty is that if the test results indicate the measured result is close to or on the limit in the standards, then compliance can't be guaranteed if the uncertainty of measurement range goes beyond the wrong side of the limit. So usually compliance can only be declared with certainty where the measured value and the measurement uncertainty range together fall within the limit values in the standards.

The most formal testing requirements involve obtaining an "endorsed" compliance certificate and test report from a recognised accredited test laboratory. The endorsement on the certificate or DoC is a statement by the test facility, including the logo of the accreditation body which assessed the capabilities of the test laboratory, to certify that the testing was performed in accordance with the conditions of the accreditation. In this case, usually the test report has a list of the test equipment used, their calibration dates, and a calculation of the degrees of uncertainty of the performed measurements. Any measurement criteria outside of the scope of the laboratory accreditation cannot be included on this kind of test report, so it's important for the compliance engineer to ensure that all the required tests have actually been performed with the required accreditation, otherwise the DoC cannot not definitively apply to the whole product.

Some laboratories go even further than that. They may require inspecting the factory or site where the product is manufactured, or where it takes its substantial form, and certify the manufacturing and quality systems. This is to ensure that the company can reliably manufacture all their products of the same kind to the required standards, not just the samples provided to the test laboratory. In some cases, the manufacturing facility may be inspected on a regular basis. And going even further, the test laboratory may select products at any time from production for retest to ensure ongoing compliance.

Laboratory accreditation

While the accreditation of the test laboratory is not usually the product compliance engineer's responsibility, the compliance engineer does still need to check that the test laboratory is accredited for testing the required standards by an accreditation body that is recognised by the applicable government regulators in the target product markets. International and national accreditation systems exist, and sometimes the government regulator itself requires testing to be done in a specific in-country government-authorized test

laboratory. So, testing and certification of the one product may need to be done several times in different places to meet the requirements of different government regulators.

Where different regulatory or technical requirements conflict with each other, for example operation at 110 V 60 Hz for North America vs. 230 V 50 Hz for much of Europe, multiple products that meet the different requirements may need to be developed, or, where possible, the products can be built to incorporate configurable or automatic compliance with differing national requirements. Each of these product variations need to be tested for their respective geographies, so that a product that can operate in both voltage ranges in the above example is actually tested for compliance in both ranges (this example can impact safety and electromagnetic compatibility compliance).

Regulatory agency approval

The process doesn't necessarily end with the compliance certificates and test reports. Some government regulatory agencies require the compliance-evidence documentation and possibly samples of the equipment to be submitted to them for inspection, evaluation and approval before they permit the product to enter their market. Usually there are specific product compliance or approval markings required on products by different government agencies, some of which can't be applied until after compliance and government approval has been obtained. In some countries, the certificates of approval must be shipped with the products for inspection by customs officials at the borders.

Regulatory approval doesn't always last forever. Some regulations permit the product to be sold for an indefinitely long period, so long as the product remains the same. Some government approvals apply strict time limits to how long the approval is valid, after which it must be extended or renewed or withdrawn. Periods can range from 1 year to 5 years for example, or occasionally approval to supply could apply to just a single machine in special cases, such as for use in tradeshows or exhibitions. If not extended or renewed in time, the product must usually stop being sold or supplied to the market until valid approval is re-established, even if the product complies fully with the applicable standards. Some approvals require the supplier to monitor the changes to the regulatory standards over time, and if there are any critical changes applicable to the product, the product is required to be bought into compliance with the new requirements.

Records retention and auditing

While obtaining certification and regulatory approval is required to bring products to market, an important part of the process is to keep records proving compliance and approval for a reasonable time. Some government regulators specify strict minimum requirements for records keeping, such as a minimum of 5 years after the product has stopped being sold. During this time, they may ask the supplier to make the records available for regulatory audit.

Since many products may be sold and supplied for several years, this means that records in these cases should be kept much longer after the certification documents have been signed and filed. If there's a compliance incident report at any time during the product-use life cycle, such as an alleged safety incident or electromagnetic interference with licensed radio communication services, the compliance records may be required to prove that reasonable and adequate compliance measures were taken at the time the product was put onto the market. While this might not remove all liability for proven loss or injury (strict liability exists in many jurisdictions), it may very well be a mitigating factor in the extent of liability penalties.

Standards development organisations

Many organisations develop public standards documents that may be used by product developers to ensure safety and interoperability and compatibility of equipment and systems or collections of equipment. Publicly available standards and specifications (PAS) are usually made available for sale to all who want to use them on a reasonable and non-discriminatory (RAND) basis, while some other standards may be made available to users free of charge, and some standards documents may not be publicly available but only made available in confidence where contractual arrangements exist between the parties to an agreement. Standards are voluntary when published unless referenced in legislation or regulations or contract. However, the SDOs are usually not able to make standards mandatory themselves.

Standards documents are usually developed by an SDO in an open, transparent and inclusive manner via consensus processes, which means there is general agreement between expert committee members, and there is no major sustained objection to the content.

A lower consensus technical document, and documents not produced by a recognized SDO are usually referred to as a technical specification. A technical specification also defines "*requirements to be fulfilled by a product, process or service*"[3] as well as how to determine that the requirements have been met (compliance). Specifications and standards may, and often do, reference each other.

Another type of standards document comprises technical regulations. These are documents that have technical requirements that are determined by rules under binding government regulations or decree, and usually enforced by a government authority (that is, a regulator). Often these are developed in a consultative process, by notification to industry and others that the government or regulator intends to make a regulatory standard, and outlining the nature of the document, and seeking community input which the government or authority may at their discretion take into account before finalizing the document. In this case, consensus doesn't have to be achieved. Technical regulations and similar documents may incorporate all or select parts of any other technical standard or modified parts of other technical specifications or be fully or partly self-contained.

International SDOs include the International Standards Organization (ISO), the International Electrotechnical Commission (IEC) and a Joint Technical Committee of these called the ISO/IEC JTC 1 (sometimes called JTC 1 for short). There's also the International Telecommunications Union (ITU) who make "Recommendations" which are often treated as international standards for radio (ITU-R) and telecommunications (ITU-T). There are other SDOs as well. International standards are often characterized by development by the worldwide community at government or national level. There are some worldwide SDOs who are independent of government, such as the Institute for Electrical and Electronic Engineers (IEEE), however this could also be regarded as an industry SDO with broad reach.

Regional SDOs look and operate a little like international SDOs, except the participation and applicability of their documents relate to a specific multi-country region or economic area, and participation is broader than national representation. Some examples

[3] ISO/IEC Guide 2

include the European Telecommunications Standards Institute (ETSI), European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the Pacific Area Standards Congress (PASC), to name a few.

National SDOs are usually those who are set up by government or endorsed by their national government for writing national standards for their own country. The national SDO is usually the representative for that country at the ISO or IEC (for the ITU, membership is usually that of a governmental authority of each member country). There can be more than one SDO for a country, but only one can be represented and have one vote in an international SDO, although they may send multiple national delegates. Differing models of participation in national SDOs exist, however they generally aim for balanced stakeholder representation for their economies and develop standards on a relevance and national net benefit basis. Many of the standards are referenced by government or regulators for mandatory application in their country.

Often national SDOs adopt international or regional standards as their own national standards. The first preference is direct-text adoption where there are no technical changes, but if national conditions require some differences to international standards then those are developed and published with national differences and notified to the IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE) for laboratory testing purposes, as well as the World Trade Organization (WTO) as potential non-tariff technical barriers to international trade (TBT).

Consortia are those SDOs comprising a range of collaborative business participants which have a wider community acceptance. Examples include the Internet Engineering Task Force (IETF), the World Wide Web Consortium (W3C), the 3rd Generation Partnership Project (3GPP) for mobile phones standards, and the Bluetooth Consortium. They were usually set up for a specific purpose to achieve an objective quickly, but often have ongoing reasons to continue their work.

Industry standards groups are like consortia, where technical documents are developed by groups of common industry participants to specify technical requirements to be used by members of that industry. Examples include the Semiconductor Industry Association (SIA), Society of Motion Picture and Television Engineers (SMPTE), and the Storage Networking Industry Association (SNIA).

Corporate standards are a company's own private standards documents, developed independently for the purposes of use in their own product development. In many cases they reference materials from the PAS of other SDOs. In this sense the corporation is not considered an SDO because their standards are not usually used by other organisations, except in performing work under contract for that corporation.

Other equipment manufacturers (OEMs)

At first glance, the role of OEM products and parts in the compliance engineering story may not be well understood, however special care is still needed in specifying their requirements and certifying their suitability. They basically come in two kinds: OEM-in, where parts from other manufacturers are procured for incorporation within the supplier's own product, and OEM-out parts, where the supplier's own-brand parts or products are supplied to other manufacturers for incorporation into other products, with or without re-branding.

Often, but not always, government regulations have lesser impact directly on OEM parts when they're intended for remanufacturing into another product that itself will be required to comply with requirements. In any case, the parts must still meet their stated specifications so that they're suitable and fit for purpose in the target application. Product developers need to be very careful that they're using the parts in accordance with the OEM's stated purpose, instructions, ratings and specifications. For example, a pre-made100 Watt open-cage power supply might be selected for use within a computer or multimedia system, but the OEM-in assembly must be checked in the containing product for safety, electromagnetic compatibility, mechanical fit (form factor) and stability, electrical connections, voltage limits, overcurrent protection for that application, minimum power rating to cover the maximum power draw in the product, ventilation and cooling, temperature rise, orientation, and so on. Even if the OEM part is certified for safety and EMC compliance in its own right, the integration into another product can affect overall product compliance, and if any modifications are made to the OEM part, like drilling a hole for mounting, or removing a cover to save space or improve fit, any certifications for that part might be rendered void.

Packaging and documentation

Packaging is usually required for shipping and storing the product to protect it from damage during shipping and handling and to keep all the bits and pieces together that it needs to operate. It's rare for an AV/ICT product to be sold or shipped in the raw without packaging of some kind. For example, a printer would normally be shipped in a box with toner or ink cartridges, a power cord set, maybe an interconnection cord set, and at least a quick setup guide. Sometimes there'll be a full instruction manual on an included disk or a link to a web site where the full instructions can be downloaded. Some documentation may be legally mandatory as part of the equipment certification, for example instructions on how to install and operate it safely.

There'll be a range of shipping labels as well on the box, some for equipment identification, inventory tracking, and some for regulatory purposes if required, and a delivery address space provided as well. If the box is particularly heavy or the contents fragile, there needs to be warnings for lifting and handling, and sometimes the device needs to be shipped in a specific orientation, or maybe have stacking height limits which are indicated. If it contains hazardous batteries or other materials, there needs to be appropriate labelling indicating the nature of the risk and the hazardous parts need to be protected in a prescribed way.

The disposal or return of the packaging also needs to be considered. Is it suitable for recycling? Does it have any environmentally toxic or landfill components? Will the supplier take back the packaging, so the customer doesn't have to dispose of it?

The product design doesn't stop with the product itself, but includes all the above matters, some of which are subject to mandatory regulations or compelling business requirements.

Legal

General

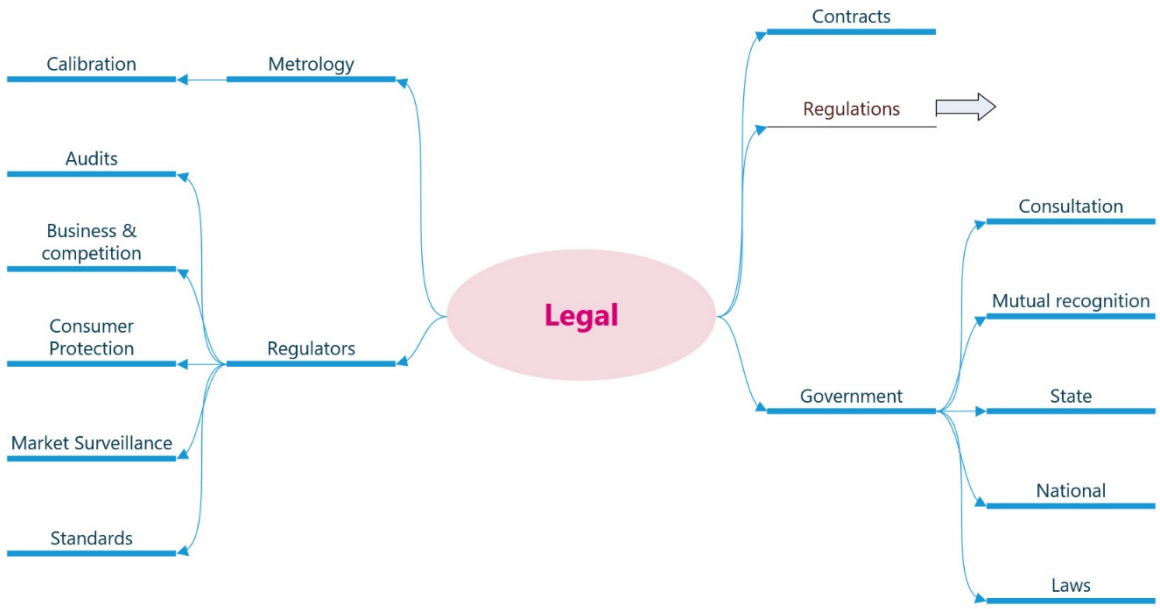
Many legal obligations are imposed on products that must be complied with according to the law of the land where the product is manufactured, imported, and sold. Standards and compliance engineers are not usually expected to have formal legal qualifications, however a

practical-level knowledge of legal matters that affect all aspects of product development, sale and use is vital to protect the business from litigation, bans and recalls. The cost of remediating any of these can far outweigh the business case of placing a product on the market without adequate inclusion of applicable legal matters, and penalties may even include personal criminal convictions for company directors which can't be monetized.

The legal framework in which a standards and compliance engineer operates and must be aware of, particularly for the AV/ICT industry, is shown in Figure 4. The hierarchy is:

- Government (Extra-territorial, National, State, Local),
- Regulators,
- Regulations,
- Referenced standards.

Figure 4- Legal framework for AV/ICT compliance



There is also a hierarchy of applicable technical documents that standards and compliance engineers need to understand and apply. Technical document requirements must be applied basically in the following priority order:

1. Laws (National, State, Local),
2. Regulations,
3. Mandatory standards,
4. Contracts,

5. Voluntary standards, and
6. Product specifications.

If there are conflicts between the requirements of any of these documents, the higher-level document takes precedence. For voluntary standards and product specifications, this precedence applies where the product specifications call up the voluntary standards. The specifications may freely modify the application of voluntary standards, but in that case compliance with the voluntary standard might not be able to be claimed in these special cases. For regulations and mandatory standards, deviations from the expressly stated minimum requirements is usually not permissible, but sometimes the government agency or regulatory authority might give exception approval on request under exceptionally justified circumstances, but only where the law permits such flexibility. For contracts, compliance may be negotiable.

Government

The government is the ultimate law-setter of the land, and models of government vary widely from country to country and economic areas. Not all country models have three levels of government, and some governing models may even have extra-territorial application (for example the European Union governs its member States – which are countries, who govern their internal affairs in turn). Usually there is some level of coordination and hierarchical management of government functions but overlaps and discontinuities do exist. For example a national government may develop laws for energy efficiency of electrical equipment and apply those laws nationally, while multiple State governments might each have their own laws about safety of electrical equipment, which they usually try to harmonize across the country and mutually recognise between all States to facilitate trade between States. Local governments (where they might exist) can be responsible for local recycling services, landfill and waste management services, but under rules set by a higher-level government about what is permitted to landfill and where, and how and what requires special disposal. Consumer protection laws might apply at both the national level and the State level, with often overlapping requirements.

Governments write legislation (laws) covering many aspects of product technical specifications, usually at a high level to outline the objectives, application, penalties, and define who will administer the laws and act in the government's name – that is, the regulator

or government agency. The government through laws assigns powers to the regulators and defines how they are to be funded and operate and whether they can issue penalties for non-compliance and when and how much. The laws can be very lengthy and difficult to read, but an understanding of how they apply to products compliance is of vital importance, as well as a mechanism and knowledge of how to determine what applies and that compliance has been achieved.

Sometimes the government itself will publish the technical requirements needed for technical regulations and sometimes it will assign that responsibility to the regulator, giving parameters or scope within which the regulator must confine their activities. In many cases, although this will vary in some countries, the government will consult with the community, industry and others affected by any proposed new or changed requirements (known as “key stakeholders”) before implementing its final requirements.

As mentioned before, consultation does not mean consensus. The government may ask for public and industry views on its proposals but is still free to publish whatever it wants after considering such input. Once published in an official format with assigned or automatic application dates, it becomes law. If all goes well, the new legal requirements will give suppliers some reasonable transition period to implement before they become mandatory, but it’s not unusual for technical requirements to become mandatory on publication, so the standards and compliance engineers need to track this activity carefully, and bring it to the attention of the business and their legal staff as well as product developers when it impacts business and development processes, and find a mechanism through which its corporate or industry perspectives are made known for consideration in the government’s consultation process.

Regulators

Government-appointed agencies whose role it is to administer technical regulations in defined areas are known as regulators. There are many and exist at all levels of government. There are strict laws in most places about how industry works with government regulators, which need to be clearly understood and applied by compliance engineering personnel or whoever is representing the supplier’s interests. The same applies to interactions with government processes as well. There is no single model for regulators, except that they may interact with each other for the purposes of mutual understanding and mutual recognition, and

they very often watch what's happening in other jurisdictions and in other countries to be better able to manage their own regulatory domains.

Sometimes there is overlap in scope between different regulators, for example regulations dealing with consumer protection at the State level might have similar regulations at the national level, and regulations dealing with State electrical safety issues also deal with some specific consumer protection issues, so determining which specific regulations apply can be challenging. However, where discrepancies arise, the most onerous of the sum of requirements apply. Where there is simple overlap, such as reporting of non-compliance incidents or harm, the requirements of each jurisdiction need to be satisfied. In some cases, there may be arrangements between the regulators that only one needs to be notified and they will notify the others. Where there is regulatory conflict (one regulator requires something different to the other) then this needs to be resolved too.

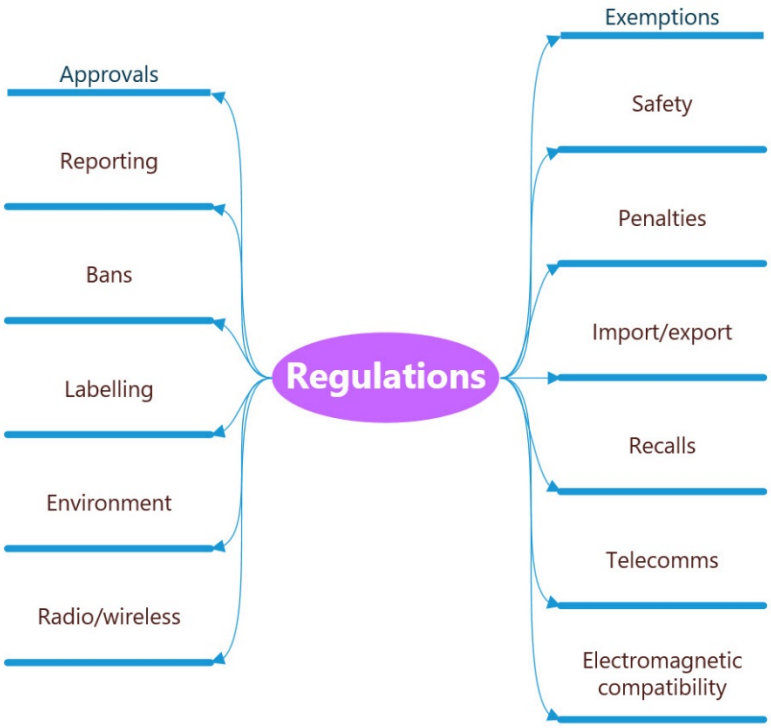
In short – all applicable laws and regulations must be complied with, with no unapproved exceptions. This is one reason why regulators talk to each other – to clarify what to do in the case of overlap or conflict. Usually resolutions can be managed via inter-governmental agreements (IGAs) and mutual recognition agreements (MRAs), remembering that the regulators don't write laws – they administer and apply them for governments.

When developing new regulations, the regulators usually also consult with industry and the community in a process like the government consultation on legislation, and also implement a regulatory impact statement (RIS) – an analysis on how the proposal will affect the community and economy, both pros and cons. However, the final form of the regulation can be at the government's portfolio Minister's sole discretion, but it would be unusual for a Minister to go against the recommendations of their own departments and regulators. New and changed regulations usually have a start date which, if not otherwise defined, can be immediately on publication on an official government legal document service or automatic as defined in other legislation. So, industry needs to monitor and track technical regulatory developments constantly to ensure they're aware of their new and revised obligations under an evolving regulatory framework. Ignorance of the law is usually not accepted in court or by the regulators as an excuse for non-compliance.

Regulations

Regulations can be set by either government or the regulator, depending on the requirements in the enabling laws. Some of the types of regulatory matters they deal with are diagrammed in Figure 5.

Figure 5- Legal regulations



Penalties for non-compliance may apply, as usually defined in the regulation or the enabling legislation, and they can be quite heavy, ranging from regulator-issued on-the-spot fines (which the supplier can challenge in court if needed) to direct court action, and in the most serious cases even criminal sanctions. So, regulations usually come with some sharp teeth!

Technical regulations can reference pretty much any technical document the regulator wishes to refer to, or the regulator can develop their own technical requirements (such as Determinations or regulatory standards) outside of public standards process if the law permits and they feel the need, or they can develop requirements based on public standards but make changes to anything in the public standard or add new material.

One thing the regulations can't do is apply requirements outside the heads of power of the regulator under the enabling legislation, even if the requirements are on the same topic. For example with telecommunications regulations, where the laws may be written to restrict regulatory matters for equipment connected to public networks to safety of all users of the public network and cause no damage or interference to the network by attached equipment, the regulator might not be able to write regulations which specifies that a telephone has to have certain types of push buttons (or any pushbuttons for that matter), and the regulator might not be able to write a network regulation requiring the public network utility what features and technical requirements may be required in their networks (with some isolated exceptions). So even laws have limits. On the other hand there may be unintended application of laws as well if things aren't fully defined – for example what does "connected to a public network" mean and does it apply to equipment that's only logically connected to the network, or indirectly connected to the network as well? This has been a real technical conundrum in Australian law that has engendered many and varied debates for many years.

Technical regulations may specify the product approval requirements, document retention, and product labelling requirements to show the approval process and technical requirements have been complied with. Sometimes they don't require the products to actually work, as in the cases of safety and electromagnetic interference (EMI) regulations, but the consumer protection regulator will take issue with suppliers who have products that aren't fit for purpose and working as claimed. The regulators also usually reserve the right to audit the supplier's records at any time and sometimes do check-testing of their own, which the supplier has to pay for if the check testing fails, along with remedial action expenses and possible penalties.

Reporting

Some regulations have reporting requirements for suppliers to notify the regulator of certain things within specific time frames. A significant reporting requirement in several countries is to report if anyone is allegedly injured by a product. The alleged injury or death doesn't have to be proven first – but it must be reported to the safety authorities within a short time frame (for example 48 hours in Australia) of the supplier becoming aware of the alleged incident. In these cases, the regulators require anyone and everyone in the distribution and sales channels who becomes aware of the allegation to report it. They'd rather receive multiple reports than none.

Another common reporting requirement is for the supplier to notify the safety regulator within a short time period of the supplier commencing a voluntary safety recall for their product. The regulator will work with the supplier to ensure the recall is carried out effectively to the appropriately targeted recipients.

Not all reporting is for safety matters. In some countries there are other reporting requirements concerning the number of goods of a regulated kind sold by a supplier over a specified period[4]. Other reporting requirements may exist as well. The compliance engineer needs to understand these and ensure the business processes are configured to respond appropriately within the mandated regulatory time frames.

Contracts

Contractual requirements are legally binding between parties to a contract. Resolving interpretation and dispute resolutions in such contracts is usually a private matter between the parties, or could be a matter for independent mediation and arbitration too, but ultimately the binding nature of contracts is underpinned by contract law in the case of business to business contracts, or consumer protection law concerning warranties and representations about the features, suitability, fitness for purpose, and safety of consumer goods. Especially in the case of consumer protection law, there may be mandatory minimum legal warranty entitlements that can't be written out or overridden in individual contracts or terms and conditions. The compliance engineer needs to be aware of any technical requirements in contracts to ensure they're considered in any necessary compliance certification activities.

Exemptions

Sometimes, where written into legislation or regulations, it may be possible to obtain exemptions from or alternative requirements to some technical regulations for certain kinds of supply. For example, if the product is being sold for remanufacture into another product

[4] See the New Zealand Energy Efficiency and Conservation Authority (EECA) web site at https://www.eeca.govt.nz/standards-ratings-and-labels/equipment-energy-efficiency-programme/products-under-the-e3-programme/regulatory-requirements/

there may be formal exemptions for the part. This could apply if the final product it goes into is going to be certified and approved to all the government approval requirements incorporating the part within another finished product. However, it's more usual to certify the part itself so the final equipment builder has assurance they won't run into problems down the track. An example is certifying a disk or solid-state memory drive for electromagnetic compatibility (EMC) and safety as well as listing any restricted or banned substances which may have been used in its construction.

Another exemption example may be for exhibition of one or two machines at a trade show, where the machine may be an unfinished or unreleased demonstration prototype not to be sold itself. Even so, it must be safe and not cause radiocommunications interference. Other exemptions might apply to military products, which often have their own regulations. And sometimes exemptions apply in one regulatory jurisdiction because the parameters are regulated in another, such as medical electronics have their own specialist regulator so the equipment might be exempt from the usual consumer technical safety and EMC regulations, provided they comply with parallel requirements in the specialist regulations. Electrical equipment intended for use in explosive atmospheres (for example: fuel pumps and grain silos) have their own special set of technical standards and regulations.

The important thing to note is that it's not up to the compliance engineer to decide whether a product is exempt from or subject to less restrictive requirements than specified under the applicable laws and regulations. This is the exclusive domain of the government and regulators and is only exercised in so far as the exemptions or powers to exempt certain classes of goods is codified in laws and regulations. The compliance engineer should research and understand what formal exemptions are available and understand correctly how to apply them as needed, while still noting the inviolable rule that the products must be safe and not cause interference even where exemption from full regulatory compliance has been granted.

Metrology (measurement standards)

A measurement standard is a device (not a document) that represents or produces a precisely measurable quantity, such as length, mass, time, electric current etc., within a known degree of uncertainty so that it can be used as a reference for measuring those

quantities in other objects or products[5]. There are many kinds of measurement standards, including international and national measurement standards that are recognised as measurement references for legal metrology within their jurisdictions. A "reference measurement standard" is used to calibrate the "working measurement standard" which is in turn used for calibration of the measuring instruments that are used in product testing.

So, where a government regulation or standard requires a specific amount of something, or where the product is claimed to have certain physical or electrical parameters or limits in standards, the calibrated measuring instrument indicates the measured quantity which has a dimension traceable to within a defined accuracy compared with a concise national or international measurement standard. Without such calibration, the measuring instrument's indicated readings are not much more than an approximate guess and can't be used as justification for legal or business and commercial measurements.

Marketing and Sales

General

It should be self-evident that it's marketing & sales that brings the money into the enterprise. Without these functions, product developers would have a hard time justifying the spend to build products just to sit on shelves, and the business would probably cease to exist in short order. While marketing is core to business survival and growth, it won't go anywhere without products and services, so Marketing business units and product developers, as well as compliance engineers need to work closely and cooperatively together to ensure the business objectives are met while being sure that the offered products are legally compliant and meet customers' needs. So marketing functions define what the customers want, developers design it for them, Standards engineers incorporate the mandatory and recommended technical requirements into the product specifications, compliance engineers ensure it meets technical and legal objectives, and manufacturing builds and ships it to the customers, and the

[5] See the JCGM 200 International Vocabulary of Measurement

corporation collects the income and distributes it accordingly (not forgetting the owners and shareholders).

From a product launch perspective, it's usually the marketing business unit that is responsible for defining the types of products that customers want, at the big-picture level, and they are then responsible for placing the product on the market for sale. Marketing and sales own the relationships between the enterprise and the customers, so if there are any issues with products it's Marketing's responsibility to resolve the customer-issues to the customer's satisfaction.

The role of the compliance engineer needs to be understood in all of this. Refer to Figure 6 to see some of the areas that require compliance engineering involvement in the marketing and sales functions.

Figure 6- Marketing and sales functions related to compliance engineering

Products

Marketing defines what products they want to sell and promote to customers. They set the pricing and availability dates in consultation with development and manufacturing as well as other parts of the business, and they partner to authorize shipping to customers, and get invoicing organized.

New products are straightforward and dealt with earlier, but they're not the only products that are put up for sale or supply. In supplying new products, often used products are returned to the business as trade-ins or for recycling or refurbishment or disposal. So, what is to be done with these?

Refurbishment is where a used machine undergoes a refresh and sometimes upgrade treatment process to bring it up to new or nearly as good performance as new specifications again so it can be resold. Used products, on the other hand, are those second-hand goods which might or might not have been checked for function but otherwise sold as-is, with faults and scratches and usually superficial damage being untreated, except perhaps for a cleaning process. If neither of the above processes are applied to second-hand goods, the equipment may be dismantled into its component parts for recycling and materials recovery. Essentially the parts are separated, treated, and reduced until they become suitable as part of the raw materials for manufacturing new parts. Any parts that can't be recycled are allocated for disposal (usually landfill), which must be kept to a minimum.

Laws and regulations apply to all the above, in many jurisdictions, that the compliance engineer and the business need to be aware of and attend to before the machines can be resold or shipped to recyclers. For example, in refurbishing a product, the original compliance labels and approvals may become invalidated and must be removed or obliterated if the equipment is modified from its original specifications in any way and may need to be recertified. A process is needed to ensure that only originally approved parts are used to maintain original specifications and approvals. For used machines, safety inspection and test processes need to be developed and applied, as some regulatory jurisdictions require specific inspection, test, and labelling of second-hand goods.

Merchandise is company-branded (or sometimes unbranded) products that are often given away at trade shows and exhibitions at no charge, or nominal charge, to promote the

brand name recognition and foster good will. However, the supplier doesn't want the brand name to be associated with dangerous goods, clearly because they don't want to injure people and damage the brand name. But significant and expensive safety slips sometimes happens when not managed properly. For example, promotional LED-light wrist bands have been given out for free en masse at concert events by some suppliers only to find that the button battery powering the light is accessible to and dangerous to young children. In this case, the safety regulator required the supplier to issue an expensive and very public "voluntary" recall[6]. Technical standards exist that can easily determine if these are safe for children before distribution, and it's required by law to make sure every product is safe before it's placed onto the market – even if it's for free.

Safety applies to all types of merchandise, not just technology devices. It can apply to drink flasks, back packs, clothing, costume jewelry, toys, paperweights, mouse mats, and even sticky note pads, just to name a few.

The company might choose to sell or supply OEM equipment from other suppliers through its own business channels. This can be either re-branded with the supplier's own identification replacing or supplementing the supplier information on the OEM labels (referred to as OEM-out) or can be sold with the OEM's own labels and brand intact. Consideration must be given as to how the compliance liability is addressed in both scenarios. If the supplier puts their own identification on the OEM's product, then that supplier becomes liable to the regulators for compliance and any non-compliances concerning those goods even where the supplier has no say in the development and manufacture of the products. For reselling OEM-branded products, the supplier should check with the OEM that it complies with all applicable government regulations and that it is certified as safe within the meaning of an acceptable and applicable safety standard.

It's the OEM's responsibility to ensure compliance engineering for their own products in the markets where the OEM sells them, however the reseller does need to do due diligence

[6] For a merchandise safety recall example, see "Cricket Australia — Promotional LED Wristband" at https://www.productsafety.gov.au/recall/cricket-australia-promotional-led-wristband

checks in any case. Many OEMs don't have that data readily available or don't know whether it complies or not, and some may treat it as commercially confidential even though there's legal requirements to comply with safety and other regulatory standards.

If the supplier wishes to import an OEM product into the country and sell it as-is, it's usually the importer's sole responsibility to ensure the product complies with all applicable standards and regulations in the target country. Any certifications and approvals the OEM might have already obtained in-country, even for a parallel-imported product of the same kind that's already being sold here by others, often do not apply to the importer unless special arrangements are in place between the OEM and the importer for the OEM to agree to be responsible for these products that they didn't import themselves.

Delivery methods

It really doesn't matter what delivery to market methods are used, such as sale, lease, rent, share, or even free, the products must always comply with all applicable regulatory standards and approvals. They must not cause interference, must comply with radiocommunications standards and telecommunications standards if applicable, and must always at least be as safe as the current values that the community have come to expect. It doesn't usually matter whether a million machines are supplied or just a few or even one. The regulatory compliance rules still apply.

For products that are not physically supplied to the market but are installed in the supplier's own premises for their own use or for remote public access via cloud services, or disaster recovery services and so on, the requirements for the products to be safe and not cause radio interference or harm to networks and so forth still apply. Workplace health & safety regulations always require products to be safe in the workplace, even if they don't have to be certified for supply to the market. Radiocommunications regulations require products to not cause interference (EMI/EMC) to other products or licensed wireless services, and products that intentionally emit radio communications have compliance standards and licensing conditions as well, regardless of whether it's supplied to the market or imported for own use. Telecommunications products too are usually not permitted to be connected to public networks unless they are certified, approved, and labelled against national homologation standards and regulations.

Another class of products is those that are used in the international transport industry, such as shipping container tracking devices that are only imported for temporary periods on shipping containers (air, sea, or land) and not sold in the country but are re-exported with a future container shipment. These require case by case assessment by the standards and compliance engineers, as function can vary significantly. Consultation with the national regulatory authorities is highly advisable to be certain the required compliances are in place.

Portable modular data centres (PMDC) are another special case. For the most part these are comprised of data centres built into one or multiple 20 foot or 40 foot modified shipping containers (they still use those units of measure in that industry) bolted together horizontally or vertically that can be moved by truck from place to place and installed in any convenient outdoor location. These are almost one-off products, each being very different to the other and involving much more than just ICT product standards, as they contain building wiring, air conditioning, ventilation, fire suppression systems, emergency exits and lighting, and sometimes diesel generation or renewable energy power systems and battery energy storage systems (BESS). They have many unique safety and compliance issues, so essentially a safety risk assessment needs to be performed for the whole installation.

With the advent of quantum computing, the standards and compliance engineers are now also specially challenged with issues concerning control devices cryogenically cooled to within a hairsbreadth of absolute zero[7]. Standards for this challenge are not yet developed and are under consideration, however many of the principles of existing standards may be applied and adapted to this scenario.

Customers

As previously mentioned, the marketing manager is responsible for all relationships with customers, however the compliance engineer has a role to play there as well, in concert with the marketing team. In most cases the customers are, or are responsible for, the equipment users. While the marketing team advises the development what the customers

[7] Parts of quantum computing processors can operate below 1 Kelvin or -272°C. See "Cryogenics and Quantum Computing" at https://www.azonano.com/article.aspx?ArticleID=5123

want designed and built, the standards and compliance engineers need to look behind the functional requirements and determine what corporate requirements and regulatory requirements must be fulfilled as well. Many customers assume this will be done and don't ask about it. Some customers, particularly larger ones, do ask for details about safety, regulatory, and standards compliance in their RFP or RFQ or RFT[8] etc., and it's often the compliance engineer who is asked by marketing to provide the needed details.

The corporation needs to monitor their products in the marketplace and offer service/repair facilities (whether in-house or via third parties) or replacements or refunds if things go wrong with the product or don't perform as specified. Spare parts need to be sourced for repairs and upgrades where appropriate, and these need to comply with the product specifications and certifications as well. If components are used for repairs that were not certified with the product there may be compliance issues. Sometimes spare parts used for replacement of identical faulty parts are not required to be certified in themselves (for example a module attached to a planar board, but sometimes the spare part does need its own certifications, approvals, and labelling (for example, an external power supply, or a mains power attachment cord set).

Seemingly simple unapproved replacement components can have a big impact on product safety and approval. Take the example of an overload fuse for instance. Where relied on for safety, these are usually intended to prevent fire in the event of equipment failure. For this reason, they are usually certified parts in themselves, and are specifically listed as critical safety components in the equipment safety test report. If they are changed for a fuse of a different kind or uncertified type, safety compliance can no longer be assured, even if the replacement fuse has the same short-circuit current rating as the original. Other factors that need to be considered are the breaking capacity and the rupturing speed (slow blow or fast blow), and if uncertified, even the rated performance cannot be guaranteed in the event of an equipment failure.

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[8] RFQ = request for quotation, RFP = request for proposal, RFT = request for tender

Bystanders (people who are nearby but not actually using the equipment) must be protected as well as the customer, and the customer is not always the sole user. This happens in the case of automatic teller machines (cash machines) or airport and shopping mall electronic kiosks, and supermarket self-checkout service centres. So, it's not just the customer who is required to be protected by safety standards. The user and bystander need to be protected, as well as the instructed person (for example the personnel who replace the cash or the printer paper roll or ticket stack inside areas of kiosks not accessible to the public), as well as the skilled or service personnel who are working on adjusting or installing or servicing the equipment.

A critical role for service and marketing folk is to provide customer feedback about alleged safety and non-conformance incidents to the development team and compliance engineers, and to also have in place a process to deal with incident investigation and resolution should the need arise. This is called an incident management plan. The incident management plan needs to involve the standards and compliance engineers, as well as the development and legal teams and should have an executive owner, which is usually the product marketing owner in the country. Since marketing is responsible for putting the product on the market and managing the relationships with the customer, it is usually their role to chair and resource the incident resolution team with expertise drawn from across the business. Every product should have an incident management plan so that an organized response to alleged safety incidents and other product compliance claims can be rapidly put together.

Competitors and business partners

Business partners and competitors can be the same organization under different relationships. They may be a competitor in some areas and business partners in other areas of the business. It's important to understand the role when dealing with these third parties and properly balance the relationships. Usually, like with customers, marketing owns the relationships with these entities.

In their role as competitors, third parties may be reluctant to share certain information with the company, and vice-versa, for fear of releasing proprietary information to competitors. Test reports, for example, can contain detailed design information for new products that might give a competitor enough internal product design information to either

copy elements of the design or otherwise take market advantage of the information for equipment that hasn't been released. For this reason, third-party suppliers are often reluctant to share complete test reports unless there's prior contractual arrangements and trust between the businesses to do so, with corresponding non-disclosure agreements (NDAs). Instead, where a compliance engineer needs compliance information about a third-party OEM product, usually the only available information is the OEM supplier's declaration of conformity (SDoC), or other official statement signed by the OEM that their products comply with certain standards.

Be careful when using these OEM SDoC documents to ensure that they truly and accurately reflect the standards and regulations known to be required. Sometimes they get it wrong, for example confusing safety standards with EMC standards or declaring "worldwide compliance" without stating which countries and which standards were applied for and proven compliant. In case of doubt make further enquiries, because a regulatory auditor will examine every document against their requirements.

Business partners (BP), on the other hand, are usually more flexible with information handling as appropriate NDAs should already be in place. But make sure of it first. The compliance engineer may be required to support the BP in making product certification information available to them so they can properly conduct their business. The compliance engineers should understand the extent and limits of any BP agreements as they may impact on their service level agreements (SLAs).

Environment

General

As several formal definitions and differing perspectives of "environment" exist, it's necessary to qualify the environment further for this paper. The natural environment is defined in its broadest context as the "*surroundings in which a product or system exists, including air, water, land, natural resources, flora, fauna, humans and their interrelation*"[9].

[9] See IEC Guide 109:2017, clause 3.3

Other concepts of environment exist, such as the business environment comprising rules, regulations and structure within which the business operates; these have been dealt with in other sections of this paper. There's also the equipment operating environment (also called operating conditions) which is the "*surrounding which may affect performance of a device or system*"[10], or the macro-environment which is comprised of the "*environment of the room or other location in which the equipment is installed or used*"[11]. Environmental aspects related to product standards and compliance engineering are depicted in Figure 7.

Protection of the natural environment

Earth's non-renewable resources are limited and are being depleted rapidly with time, compounded with worldwide climate change due to greenhouse gas emissions. Also, the biodiversity of flora and fauna is shrinking as species are dying out at an accelerating rate due to climate change and depletion of habitats. As an example, the Government in Australia says: "*Rates of extinction of species are likely to increase as the global average temperature rises by just 1.0 or 1.5° C above pre-industrial levels, and likely to accelerate sharply as temperature rises beyond 2 degrees Celsius*"[12]. It's therefore vital to manage the world's resources as well as the world's waste streams to minimize the negative impacts of technology on the global environment. Product standards and compliance engineering has a significant role to play in protecting the natural environment.

The types of issues the standards and compliance engineers deal with in terms of environment management are depicted in Figure 7 and will be discussed in further details below.

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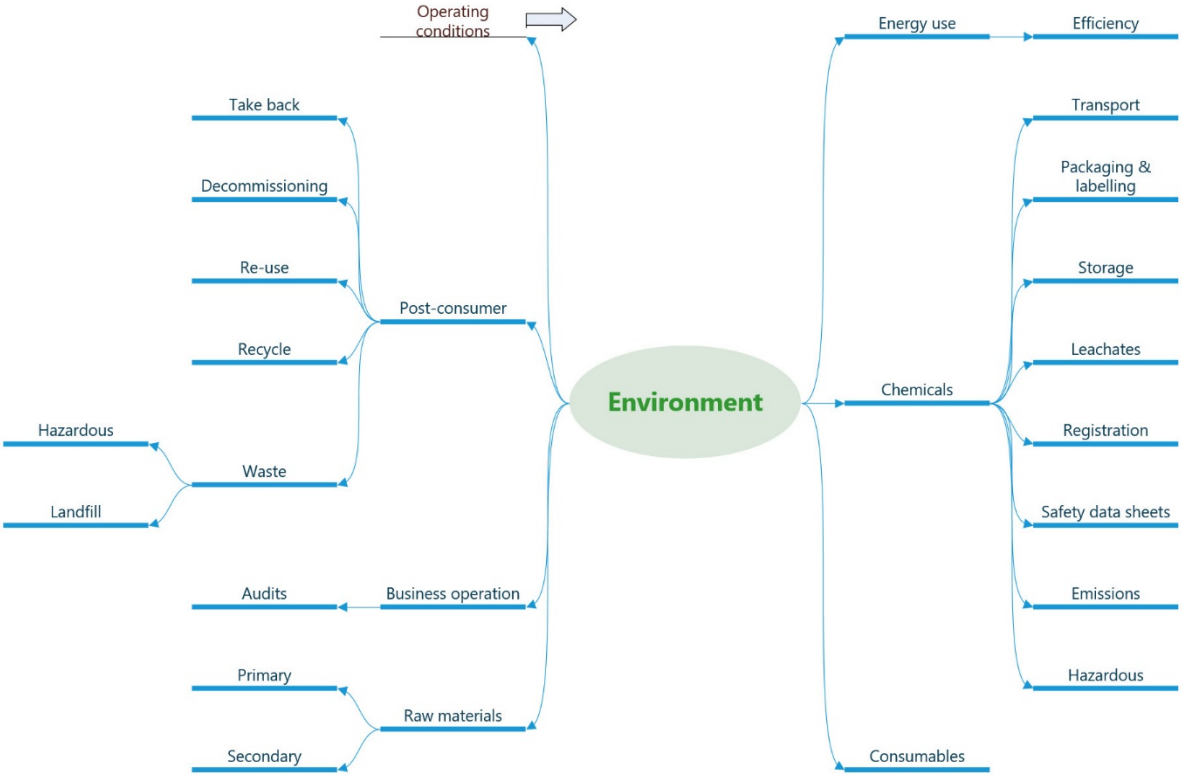
[10] See IEC 60664-1:2007, clause 3.12

[11] See IEC 60664-1:2007, clause 3.12.1

[12] Reports from the Australian government's Department of Agriculture, Water and the Environment are available at https://www.environment.gov.au/climate-change/adaptation/publications/australias-biodiversity-climate-change

Figure 7- Compliance engineering relating to environment



IEC Guide 109 indicates the objectives are the following:

"*The basis of product-related environmental protection is life cycle thinking, i.e. the consideration of all relevant environmental aspects of a product at all its life cycle stages. The key elements of life cycle thinking are:*

- *identification and evaluation of the product´s relevant environmental aspects during its entire life cycle;*
- *having an objective to minimize the overall adverse environmental impact of the product by improving the product´s environmental aspects.*"

Business operations

Businesses themselves use natural and manufactured resources and energy to run their daily operations in administration, research & development, marketing, manufacturing, data centre operations, office equipment, heating/ventilation/air conditioning (HVAC), kitchens, bathrooms, and so on.

Environmental management systems standards exist to help "*an organization seeking to manage its environmental responsibilities in a systematic manner that contributes to the*

environmental pillar of sustainability"[13]. Businesses can be audited for compliance with the ISO 14001 environmental management standard to ensure they're managing their overall business environmental footprint in a responsible, transparent and planned manner.

Product energy use and efficiency

Electrical products can use a lot of electrical energy compared to the work they seem to perform, but much of it doesn't do any useful work – it is wasted. Energy efficiency is defined as the "*ratio of output power to input power of a device*"[14] that is usually expressed as a percentage which indicates what percentage of input power is available to do the actual work. For example, a power supply that is rated at 80% efficiency might sound good, but that means it's dissipating 20% of the input power to waste (usually in the form of heat) before it even powers the product. The product will also waste some more energy in performing the work as well, for example the heat produced by a halogen ceiling lamp is wasted energy. Not only is energy wasted in use, but it's also wasted when the equipment is doing nothing but remains powered on or partly powered on. This is called standby power, and a lot of AV/ICT equipment is consuming standby power when it's not in use, so again it's wasted energy.

Basically, the user is paying for this wasted energy, but so is the environment, especially if the energy was generated from non-renewable resources, like coal or gas-fired power plants. It not only depletes the resource, but it also adds greenhouse gases to the atmosphere at the power station. The more efficient we can make the product's power profile, the more energy and natural resources and pollution is saved as well as cost savings to the users.

Many governments now have mandatory standards and regulations in place for energy efficiency of electrical and electronic products. They regulate the minimum energy

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[13] ISO 14001:2015, clause 1

[14] IEV ref 151-15-25 at http://www.electropedia.org/iev/iev.nsf/display?openform&ievref=151-15-25

performance standards for a range of products and have certification, approval, and registration requirements in place to manage and control compliance.

Chemical substances

Chemical substances ("chemicals") may be comprised of an element, a compound of several or many elementary substances that are chemically bonded, or a mixture of non-chemically bonded substances. Many chemicals have tight regulatory controls, such as regulatory listing or registration requirements[15] as well as specific storage, labelling and transport requirements, due to potential hazards and adverse health effects. Some chemicals are banned (such as asbestos) or restricted because of their negative impact on humans or the environment or have shipping restrictions and labelling requirements to prevent transportation accidents (for example some lithium batteries).

The standards and compliance engineers need to know what chemicals are restricted or banned in their geography, or have special shipping and labelling requirements, and ensure that appropriate data sheets are available to the end-user for safe storage and handling information where required, make sure banned substances are not used, as well as have access to the list of chemicals and other materials that are used in their products.

Materials

Materials are substances that are either "primary raw materials" comprising of the newly mined or collected or manufactured substances that may be reprocessed into suitable forms from which products are manufactured, or "secondary raw materials" [16] which are raw materials derived from waste that may be used in place of or as a supplement to primary raw materials. Like chemicals, the use of some materials may be restricted in products, such as

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[15] In Australia, for example, this is the *National Industrial Chemicals Notification and Assessment Scheme* (NICNAS) at https://www.nicnas.gov.au/, soon to become the Australian Chemicals Introduction Scheme (ACIS).

[16] See the European Commission Environment's Raw Materials web page at https://ec.europa.eu/environment/green-growth/raw-materials/index_en.htm

the European Restriction on Hazardous Substances (RoHS) Directive[17], which restricts the use of lead in electronic products, among other substances, and promotes increased use of re-use and recycling. Some products and materials can emit chemicals into the atmosphere, such as volatile organic compounds (VOCs), or leach chemicals into ground water. The quantity and impact of this on the environment needs to be well understood and managed, especially where regulations or health and safety apply.

Consumable materials

A consumable material is a "*user-replaceable part or piece of equipment that manufacturers place on the market for direct sale for use in equipment*"[18]. Examples include printer toners, inks, and paper. Note that this is very different to customer-replaceable units (CRU) of equipment which may reach the end of its service life before the main product, or customer-installable upgrades, such as printer drums and some memory modules.

Post-consumer issues

When the user is finished with the product or packaging, what happens then? The worst thing would be to simply dispose of it in landfill, which is becoming a scarce resource worldwide now, and has many problems of its own, such as leaching chemicals into the environment including pollution of waterways and the water table or just pollution in the ground. According to the UN Environment Program:

"*The world produces as much as 50 million tonnes of electronic and electrical waste (e-waste) a year, weighing more than all of the commercial airliners ever made. Only 20% of this is formally recycled. The e-waste produced annually is worth over $62.5 billion, more*

[17] The European RoHS Directive is available here: https://ec.europa.eu/environment/waste/rohs_eee/index_en.htm

[18] ISO Guide 114:2008 Clause 3.1

than the GDP of most countries. There is 100 times more gold in a tonne of e-waste than in a tonne of gold ore"[19].

There are many options available for the end-use situation to make effective use of the product or its component parts. Such options need to be considered and designed at the start of product design, to be incorporated in the finished product and to include the costs of the whole product life cycle in the price paid for the product up front.

Some suppliers have packaging and equipment take-back programs where the customer can return the equipment for end of life recycling or dismantlement. This may be different to trade-in where the supplier gives the customer a monetary consideration for the returned equipment against the value of new equipment. In some countries supplier take-back is mandatory, such as in the European WEEE Directive[20], or there may be voluntary industry programs funded by a range of participants.

Decommissioning a product might be as simple as unplugging it from the wall and shipping it back to the supplier or recycler. That works fine for smaller equipment, but for larger machines partial dismantlement may need to be done for handling and shipping purposes. Rather than just hack at it with a saw and sledgehammer, which would prevent re-use, the product should be designed to be easily taken apart so it retains some second-hand value and can quickly be reconstructed for use elsewhere, which leads to re-use. Parts can also be labelled at design time to indicate what materials are present to facilitate recycling during the decommissioning phase.

Equipment can be re-used as-is or cleaned up without any transformative re-engineering work, or it can be repaired, or refurbished and sold as near new specifications or with upgraded functionality. Alternatively, equipment can be separated into spare parts for re-

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[19] See "UN report: Time to seize opportunity, tackle challenge of e-waste" at https://www.unenvironment.org/news-and-stories/press-release/un-report-time-seize-opportunity-tackle-challenge-e-waste

[20] Waste of electrical and electronic equipment (WEEE) Directive, see https://ec.europa.eu/environment/waste/weee/index_en.htm

use in the repair and upgrade of other machines that are still in service. The marketing section of this paper further discussed some of the issues related to used and refurbished machines. The intent is to keep end of service products out of the waste stream as much as possible for as long as possible and possibly make some money on the side. These programs work so much better when sustainably funded.

For products that use recycled pre-consumer[21] or post-consumer materials, there are standards available that help declare how much of the product is comprised of recycled materials, and a symbol is defined as well – the Mobius loop (with or without a percentage number)[22].

For the resulting waste material that can't be re-used or recycled then disposal options should be considered. If the waste is hazardous to humans or the environment in any way, then it may need special treatment to render it non-hazardous or otherwise require specialized disposal facilities. Other product can go into land fill, or if it's flammable then perhaps it can go to energy recovery incineration, provided the incineration by-products are not themselves hazardous to people or the environment.

Environmental operating conditions

Environmental operating conditions affect the specifications, reliability and safety of the product in many ways. Refer to Figure 8 for some examples.

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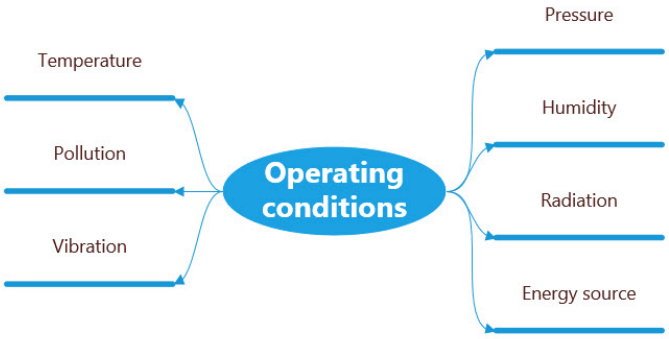
[21] "Pre-consumer" material is recycled waste from the manufacturing process. See ISO 14021.

[22] See ISO 14021

Figure 8- Environmental operating conditions



Parameters such as such as "*pressure, temperature, humidity, pollution, radiation and vibration*" (IEC 60664-1) as well as others such as input energy source quality, as well as mechanical shock from impact or dropped heights, or explosive atmospheres all have to be accounted for in product design.

No one-size fits all, so usually the product safety standards define standard operating environmental conditions and tolerances for equipment as minimum requirements for safety and functionality. For special-case usage, additional protection may be required than the minimum specified in the standards, so it's important to know where the product is likely to be used and what the operating conditions and ranges experienced are likely to be. Outdoor operating conditions, for example, are very different to indoor operating conditions.

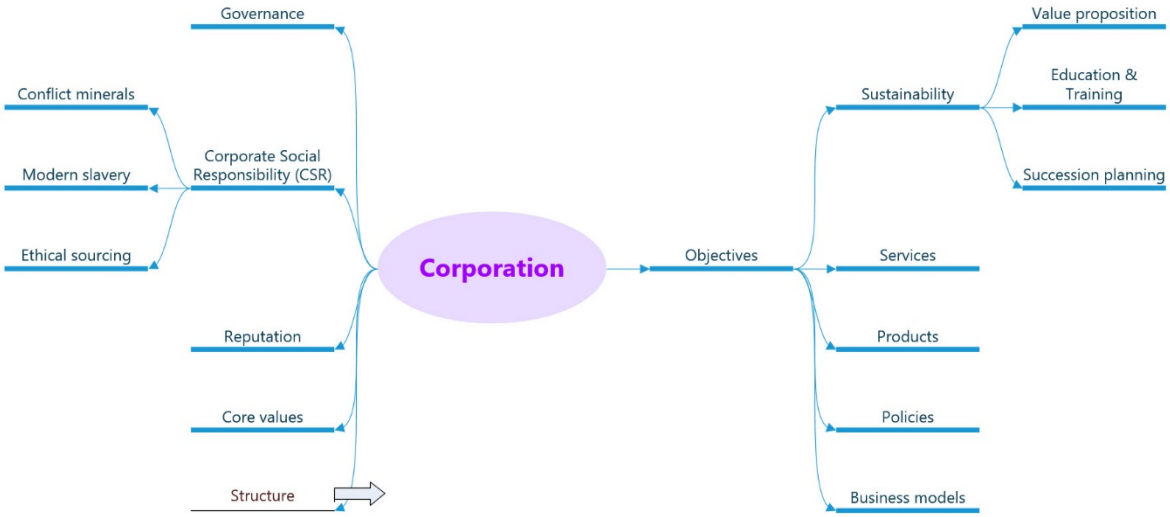
Corporation

The corporation provides the core, framework and overall structure of the business enterprise within which the standards and compliance engineers operate. For the engineers to be successful, and consequently for the success of the business, they need to be adequately resourced and supported by the business in many ways. It's not all one way though, as the engineers also need to communicate and report to the business their activities and reasons and continue to maintain solid links between their activities and the business objectives of the enterprise. Two-way communication is vital, as the reason for the engineers to be there in the first place is to support the business and to do so diligently and knowledgeably.

An outline of the functions of the corporation as perceived by the engineers is shown in Figure 9. This is not a proposed organizational model, as many corporations may be

structured differently and different models can be just as effective, however these items all need to be managed and considered effectively somewhere in the organization.

Figure 9- Corporate structure and objectives issues for the engineer



The corporation defines and sets its objectives and regularly monitors and manages its progress to achieving those objectives in the timeframes and budgets allocated for the purpose.

In the AV/ICT industry, technology and product changes occur so rapidly and the product marketing life cycles are so short that the engineers need to apply constant learning of new technologies, information about competitors so the products can compete and outperform in form and function, relevance and margins in the marketplace, and they need to have agile responsiveness to new demands of the business, as well as standards and regulatory demands. Personnel changes occur rapidly in this industry, so succession planning is important as it can take a long time to adequately train a recruit in their job responsibilities. Day to day backup resources may be required to cover the engineer's role for planned and unplanned absences.

Corporate social responsibility is becoming increasingly important in product compliance and certifications. Some customers and indeed some government regulations are

requiring certification[23] by the business that conflict minerals are not used in the production of their equipment[24]. Conflict minerals are those where "*in politically unstable areas, the minerals trade can be used to finance armed groups, fuel forced labour and other human rights abuses, and support corruption and money laundering*"[25].

Ethical sourcing includes conflict minerals and modern slavery issues but is a much broader subject which ensures products and materials are sourced responsibly and sustainably. It is a process that also verifies that the workforce is being treated fairly, and not subject to modern slavery, and there are no illegal activities or human rights abuses anywhere in the supply chain. Many suppliers and large customers are requiring their suppliers to sign ethical sourcing undertakings for their products, so it's an important business objective to meet.

The structure of the corporation should consider how and where the items in Figure 10 are to be handled and managed. R&D (development), manufacturing, legal and marketing have been dealt with in detail in other parts of this paper. The reason they're mentioned here again is to show they don't exist in isolation but are part of the bigger picture that makes up the corporation.

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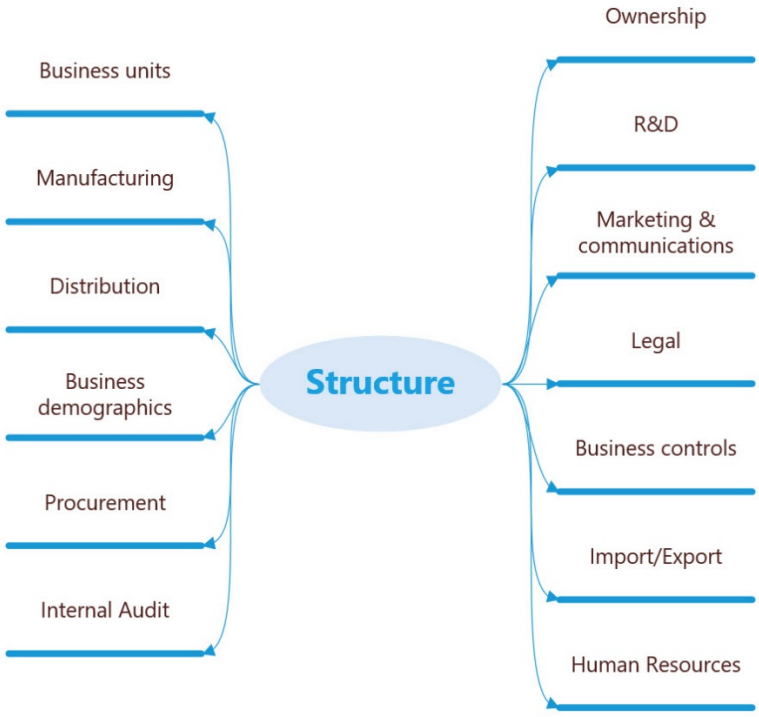
[23] As an example, "*On 1 January 2021 a new law will come into full force across the EU – the Conflict Minerals Regulation*". See https://ec.europa.eu/trade/policy/in-focus/conflict-minerals-regulation/regulation-explained/

[24] The USA also has legislation on conflict minerals: Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Act of 2010.

[25] See the Europa link above.

Figure 10- Corporation structure



Internal audits, or less formal peer reviews, are an important function to ensure the business units are meeting their objectives and are complying with corporate policies and processes.

Procurement functions need to be aware, before they authorize the acquisition of products, parts and services, that the compliance engineering processes have been fulfilled for incoming items. Remember that it's important to ensure that all the products and parts procured for use in the business or re-supplied to the market are safe and won't interfere with other products or wireless communications, and that appropriate regulatory approvals have been obtained where necessary. So, procurement has a role to ensure compliance engineering staff have reviewed and approved the products' compliances.

The import/export and distribution functions also have a role to play in concert with the compliance engineer. Some countries have import requirements for products to be inspected at the border along with the product's approval and certification documentation before they're allowed into the country. Many delivery delays have occurred as a result of not having the required approval documentation and sometimes they even inspect the labelling. As well, products must have the appropriate safety packaging and labelling for transportation if they are classified as dangerous goods. The last thing a company wants is to bring down an

aircraft because of dangerous goods, yet airline safety incidents relating to product failure do occur[26].

Manufacturing

Manufacturing's role is to fabricate the product to the engineering team's designs and requirements, and in the quantities and time frames and possibly budgets requested by the marketing team, while ensuring that every individual product item is identical with the certified and design. A functional outline is sketched in Figure 11 below.

Especially for newly developed products, manufacturing needs to keep in touch with development concerning any issues with interpreting the documentation and specifications or issues in the supply of the preferred parts or sometimes concerning the difficulty of the build so these can be streamlined and resolved. Sometimes multiple alternative suppliers of scarce or critical parts may need to be sourced and qualified against the product's specifications to ensure ongoing continuity of supply.

The company needs to decide who is to do the manufacturing and where. It can be done in the company's own fabrication facilities, if there are any, or a third-party fabricator can build the product on the company's behalf. Products can be made locally or in another country at one or at several locations. In all cases, a quality management systems (QMS) approach is needed to ensure the same product comes out of production every time, no matter who makes it and where. The plants and their QMS are often inspected and audited by third parties to international standards or local standards or regulatory requirements in some cases. In the case of third-party manufacturing plants, it's also necessary for the supplier to ensure they inspect the plants as well.

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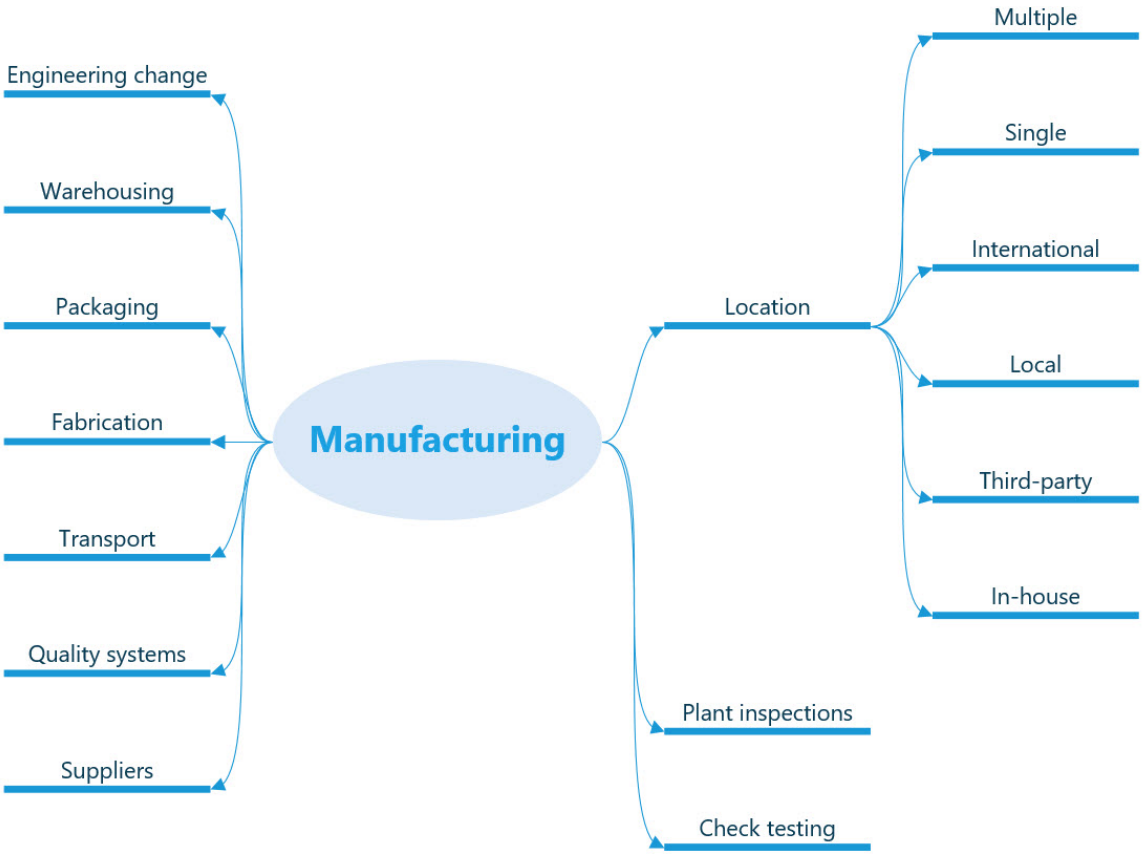
[26] See the Federal Aviation Authority's online document: "*EVENTS WITH SMOKE, FIRE, EXTREME HEAT OR EXPLOSION INVOLVING LITHIUM BATTERIES*" involving a range of products containing lithium batteries at: https://www.faa.gov/hazmat/resources/lithium_batteries/media/Battery_incident_chart.pdf

Figure 11- Manufacturing considerations



The manufacturing plant also needs to perform appropriate periodical production sample check-testing at important phases of production to ensure that no manufacturing errors have crept in and compromised the product's compliance with regulations or specifications, especially safety. These production check tests don't aim to reproduce all the product compliance type-testing, as that is often destructive, however a subset of reduced non-destructive testing can be done to check safety integrity and basic function.

Any engineering changes (ECs) needed to expedite manufacturing or improve the product design need to be carefully considered in consultation with development and fully documented and tracked. If it's likely to affect compliance, the product or the EC may need to be re-tested and certified by the compliance engineering team or authorized third parties if required by regulations.

Industry groups

Standards and compliance engineers need to liaise with and through appropriate industry groups to keep abreast of standards development, learn of the changes in the

regulatory environment that may affect their business and form a unified voice to government and SDOs on technical standards and regulations matters. In some cases, the industry group may even write their own technical standards, for example the Institute of Electrical and Electronic Engineers (IEEE). Some of the larger industry bodies provide education and training for their members as well to improve their skill sets. See Figure 12 which summarises some of the standards and compliance-related functions of industry groups.

Figure 12- Industry groups standards and compliance role

In some countries, in order to participate in national standards activities, it's not possible to represent your own company. Instead, to participate in the development of national standards it's necessary to represent an industry sector. Industry groups provide a stepping-stone into the SDO standards development process in these cases. Note that in these cases the standards delegate is representing a broad cross-section of industry views, not their own corporate position, so it's important to get industry support before proposing a controversial position in a standards committee. However not participating in industry groups and particularly standards and regulatory development may be leaving it up to competitors to set market directions and influence regulations to favour themselves and gain possible market advantage over their competitors.

Intra-company coordination

For smaller companies, the reporting and functional interconnections may be very straightforward and clear. For larger corporations many complexities can impede effective communications and coordination of activities, especially where this needs to happen across different business units and functional departments. As can be seen from the preceding parts of this paper, there is much coordination needed between different and disparate parts of the business to meet all a company's technical specifications and regulatory obligations. The corporation needs to work out the best way for communications to happen across the board.

Figure 13-Intra-company coordination

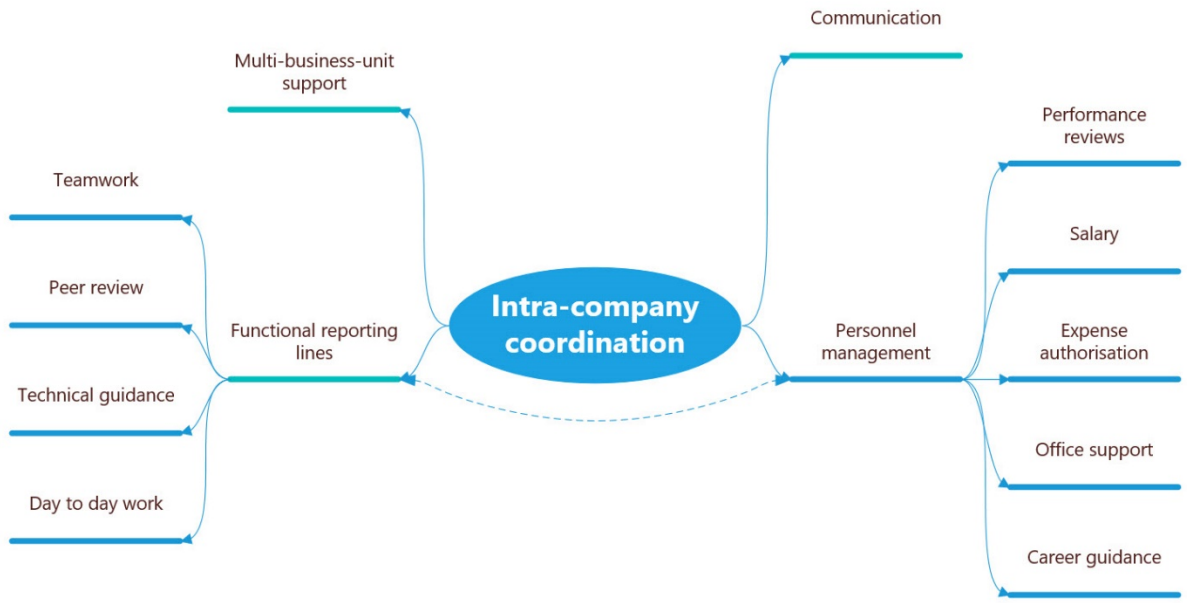


Figure 13 shows that the functional reporting lines needed to do the day to day engineering work may be different to the engineer's management reporting lines where performance reviews, expenses, and personnel matters are handled. Compliance engineers often need to work across multiple business units in multiple locations and geographies, to complete their tasks. Whatever organizational arrangements that works best for the corporation is fine, so long as planning and tools are available to foster effective and efficient communication between all parts of the business who need to work together.

Conclusions

The role of the standards and compliance engineer is both extensive and embedded deeply into an organisations very fabric, yet it's often unrecognized and under-appreciated until something goes wrong. When things do go as planned the standards and compliance engineer can be invisible to much of the business, yet it is a necessary and essential cost. When things don't go as planned it can stop large parts of business operations and impact negatively to a substantial level on profitability, customer relations, industry relations, regulatory relations, and government relations. This paper has shown that the work performed by the role is essential to a company's vitality, but how the company goes about ensuring the role is adequately resourced and qualified and operational is a matter for each corporation to decide for itself.

Abbreviations list

The following abbreviations are used or referred to in this document.

Table 1- List of abbreviations

Abbreviation	Definition
3GPP	3rd Generation Partnership Project (mobile phones)
A/V	Audio-visual equipment
ACIS	Australian chemicals introduction scheme
BESS	Battery energy-storage system
BP	Business partners
CEN	European Committee for standardization
CENELEC	European Committee for electrotechnical standardization
CRU	Customer-replaceable unit
DoC	Declaration of compliance
EC	Engineering change
EECA	Energy Efficiency and Conservation Authority (New Zealand)
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ETSI	European Telecommunications Standards Institute
HVAC	Heating, ventilation, air conditioning
ICT	Information and communications technology equipment
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IEV	International Electrotechnical Vocabulary (of the IEC)
IGA	Inter-governmental agreement
ISO	International Standards Organisation
ITU	International Telecommunications Union
ITU-R	ITU radio communications recommendations
ITU-T	ITU telecommunications recommendations
JCGM	Joint Committee for Guides in Metrology
JTC 1	Joint technical committee 1 of ISO/IEC

Abbreviation	Definition
MRA	Mutual recognition agreement
NDA	Non-disclosure agreement
NICNAS	National industrial chemicals notification and assessment scheme
OEM	Other equipment manufacturer
PAS	Publicly available specification
PMDC	Portable modular data centre
PSES	Product Safety Engineering Society (of the IEEE)
QMS	Quality management system
R&D	Research and development
RFP	Request for proposal
RFQ	Request for quotation
RFT	Request for tender
RIS	Regulatory impact statement
RoHS	Restriction on hazardous substances (Europe)
SDO	Standards development organisation
SDoC	Supplier’s declaration of compliance
SIA	Semiconductor Industry Association
SLA	Service level agreement
SMPTE	Society of Motion Picture and Television Engineers
SNIA	Storage Networking Industry Association
TBT	Technical barriers to trade
TC	Technical committee
VOC	Volatile organic compounds
W3C	World wide web Consortium
WEEE	Waste of electrical and electronic equipment (Europe)
WTO	World Trade Organization
YOYO	You’re on your own

References

IEC. (2005). *Guide 114 Environmentally conscious design – Integrating environmental aspects into design and development of electrotechnical products.*

IEC. (2007). *IEC 60664-1 Ed. 2.0 - Insulation coordination for equipment within low-voltage systems - Part 1 - Principles, requirements and tests.*

IEC. (2012). *Guide 109 Ed. 3.0 Environmental aspects - Inclusion in electrotechnical product standards.*

ISO . (2015). *ISO 14001 Environmental management systems — Requirements with guidance for use.*

ISO. (2016). *ISO 14021 Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling).*

ISO/IEC. (2004). *Guide 2: Standardization and related activities - General vocabulary.*

ISO/IEC. (2004). *ISO/IEC 17000 Conformity assessment—Vocabulary.*

ISO/IEC. (2014). *Guide 51 - Safety aspects — Guidelines for their inclusion in standards.*

Joint Committee for Guides in Metrology. (2012). *JCGM 200 International vocabulary of metrology – Basic and general concepts and associated terms (VIM) 3rd edition.*