Design Standards for Advanced Virgo Electronics

Advanced Virgo Workshop **Cascina, Jun 14th, 2007**

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overview

Why this talk

Virgo's evolution towards maturity will benefit enormously from some agreed "standards" in managing the design- installation (and maintenance) process effectively.
I'll make a distinction between

Standards (official Directives) -- capital S
standards (internal agreed policy) -- lowercase s

General remarks

goal

start a discussion. Some preliminary ideas are presented

what this is about

survey of other Projects/Organizations (LIGO, VLT-ESO) to learn from them and use their experience to our advantage

what this is *not* about

prescription list on what to do and how

Outline

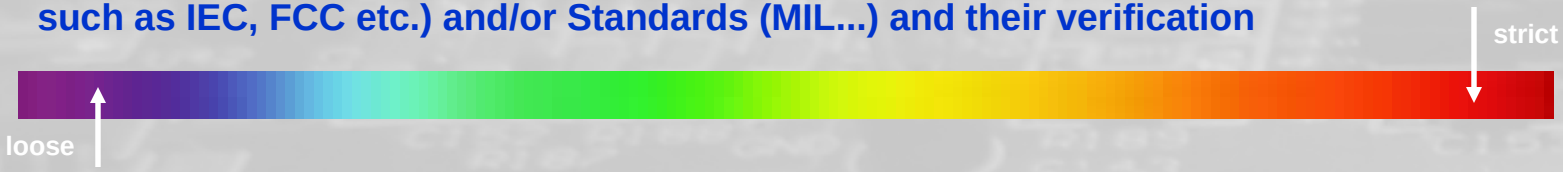
what others did (4) – what we did (1) – possible future directions (4) – Conclusions

learning from others (1)

Spectrum of possibilities ranging from

1. “strict” one

compliance with official applicable Directives (from organizations such as IEC, FCC etc.) and/or Standards (MIL...) and their verification



2. “loose” one

guidelines based on good engineering practice with an eye on official norms which constitutes a framework

Red	
Pros	**Cons**
Simple Acceptance Test (yes/no)	Verification Equipment (EMC)
No compromises (in principle)	Overkill (for us) --manpower
Blue	
Pros	**Cons**
Flexibility and “margins”	Difficulty in “drawing the line”

learning from others (2)

1. VLT- like VLT-SPE-ESO-10000-0015 (~strict one)

- applicable Specifications and Standards
  - 50 documents referenced
    - 11 internal, 25 IEC, 3 MIL, 3 EIA...
- Hardware
  - » boards
    - – compliant with Directives adopted
    - – compliant with standards adopted (such as VME)
    - – to be selected among a *finite* number of approved options
  - » cabinets (i.e., racks -- IEC 60297 and crates/chassis)
    - – compliant with Directives adopted
    - – to be selected among a small number of preferred manufacturers

but also

- » connectors (both power and signal)
  - – compliant with Directives adopted
  - – make, series and model specified

"Provisions for all functions and status signals of electronics units... accessible via LAN. Adjustments, other than those done during installation, are not allowed"

learning from others (3)

2. LIGO- like *E020986-01-D *etc.* (somewhat loose one)

- initial approach (1996): technical guidance with supporting rationale
- "a posteriori" goal (2002): targets Electronics EMC Requirements (revised) *
  - or, better, viable cures of EMI resulting from its underestimation in the early stages of the electronics (and system) design
- applicable Specifications and Standards
  - 8 documents referenced
    - MIL-STD-461 (selected portions), 2 textbooks, 2 internal...
- addressed issues:
  - inadequacies of electronics Shielding, Grounding and Power Architecture
  - consequent plan for reworking of Racks, Chassis/Crates and Interconnections with the goal of reducing EMI
- proposed solutions:
  - presents some recipes based on sound engineering to contain interference as far as feasible from the costs (economic, scientific) point of view
    - – no switching power supplies
    - – separation of analog and digital functions by rack (minimum 2 levels of Faraday shielding to separate them)
    - – EMI-shielded VME crates and racks for Digital electronics
    - – EMI-shielded crates and racks for Baseband and RF Analog electronics
    - – use of EMI feedthroughs

learning from others (4)

Lessons

- **it pays off to keep EMI in mind since day 1**
  - **minimal EMI design rules should be considered through the entire process of**
    - **– conceptual design**
    - **– schematic development**
    - **– board layout**
    - **– packaging**
    - **– cabling**

- **general philosophy of recommendation is common**
  - **although specific points may differ, as in the case of**
  - **» analog signals transmission**
    - **– VLT galvanic isolation (Power Units), ST. Coax only if length < 3m**
    - **– LIGO baseband: STPs, RF: coax (with chokes if needed)**

absolutely no barrels

What we did (1)

What about us?

Please note
NO pointing finger
Examples limited to personal experience

Apparently, in Virgo the issue was somehow underestimated @ t_0

Some consequences

1. Virgo electronics grew in isolated clusters and this brought to some interface problems

» SSFS_Corr cable: from DL to LL (48 m)

driver	single-ended	output connector	BNC
receiver	differential	input connector	3-pin LEMO

» Double Coil Current Acquisition — 3-pin LEMO "T"

2. in some cases the lack of specific requirements led to quick-and-dirty, easy-to-modify Prototype installations and commissioning which ended up being permanent

3. New relatively mysterious boxes, bench power supplies and "temporary" associated cabling keep popping up

All this has a price in terms both of reliability and, consequently, Commissioning time ⇨ we must care.

We need a solution

What we could do (1)

Solution: standards (lowercase s)

A project like Virgo cannot afford to get by relying on electronics patches (over patches over patches...)

We need to find agreements on how to do things and be consistent afterwards

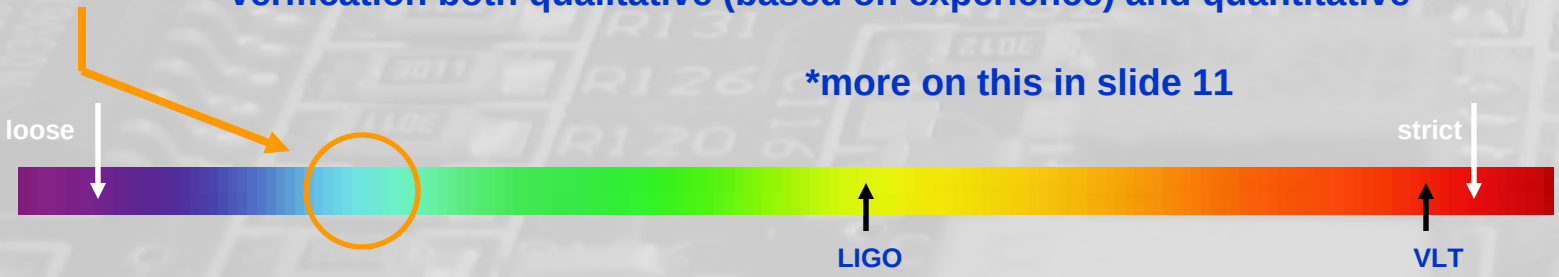
Which portion of the *spectrum* suits us best (for new designs)?

The *low frequency* region of the Spectrum is out of reach (too late and possibly too much).
In addition, different Groups are designing electronics in Virgo. Some latitude is acceptable (and welcome)

Anything we opt for, as long as *visible*, is going to be an improvement

A reasonable goal would be to aim for the *light blue window*, which means
compliance with basic Directives (starting with Safety)
verification both qualitative (based on experience) and quantitative*

***more on this in slide 11**



What we could do (2)

What *light blue* means in details?

Some examples

- » connectors
  - – no need to restrict to 2-3 the number of power connector to choose from
  - – but decision on which kind of signal connectors to use for any given “domain”
- » racks
  - – no need (till now) to choose special military-grade ones
  - – but decision on having them closed (front and back doors)
- » power distribution
  - – no need (?) to get rid overnight of our (small) switching PS (Vacuum...)
  - – but decision on suitable power distribution scheme (LL)
- » analog signals
  - – impossible to rework currently used front-end sensors (PDs, QPDs)
  - – but decision on appropriate transmission protocol(s)
- » conversion signals
  - – no special care (till now) to avoid EMI (same rack)
  - – but decision on befitting policy (Faraday shielding...)

and also

grounding schemes (star? hybrid?), cable routing (class/power, additional cable trays)...

What we could do (3): a possible path

List of proposed Virgo “standard” topics

1. Safety

seems obvious but it is not always like that (trust me)

2. Mechanical

VME, VXI... 19’’ crates, tabletop...

3. EMC, Grounding, Shielding

» Board Level

- Conceptual Design
- Schematic Development
- PCB Layout
- Packaging

» System Level

- Power Distribution
- Grounding Schemes
- Connectors (feedthroughs?)
- Cabling
- Rack/Crate requirements (if any)

What we could do (4)

Next step: Document

» Put together a draft defining the suggested standards (rigorously lowercase s) we swear to abide to based upon the previous classification. Needs homework.

» Circulate it among interested parties

» Include remarks, comments and substantiate it with relevant numbers

» Adopt it. Find agreement on policy to enforce its use

About Policy/Documentation* (from slide 8)

I cannot stress enough this point :

we have got to have a validation process that each piece of (especially, but not only, custom) electronics must go through before its installation.
No board should ever be installed unless thoroughly characterized.
A complete set of documents (Acceptance Test among them) should be permanently attached to each and every board.
I'm planning a talk on this topic for next WG4 Meeting.

Conclusions

Adoption of standards: a necessity

the payoff in terms of saved Commissioning time alone is well worth it

Light Blue Approach

minimum set of rules we agree on and will do our best to implement in all future designs

Concrete future actions

» draft on standards

It will uses Directives as reference and suggest good engineering practice to be adopted

» (draft on board documentation)

it will be presented during next WG4 (hopefully)

Question marks

any retrofit (long term)?

what about Virgo+?