# SpaceWire evolutions and standard revision

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19/10/2010

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## Outline

1. Introduction
   a. SpaceWire evolutions
   b. Backward compatibility
   c. SpaceWire standard update
   d. SpaceWire 2.0
   e. Study/Breadboarding activities
2. SpaceWire standard update
   a. Presentations (D. Jameux et al.) on technical changes to be included in the new SpW ECSS standard
      – including clarifications and some of the new features discussed earlier
      – based on aggregated Change Requests from the Working Group and related technical discussions
   b. Discussion and possibly agreement on some technical choices
   c. Presentations and discussions interleaved
3. SpaceWire 2.0
   a. Brief presentation of SpW evolutions that belong more to SpaceWire 2.0 that to the standard update
   b. Discussion on the choice of major features
4. Conclusions

# 1.e Support ESA funded activities

1. ESA funded activities aimed at supporting SpW standardisation (ECSS-E-ST-50-12C update, SpW-PnP, SpaceWire 2.0)
2. Mix of design studies and **breadboarding for validation**
3. Intended ITT “SpaceWire Evolutions”, 150k€, end of October 2010
4. Intended ITT “Network Discovery Protocols”, 200k€, end of November 2010




# 2. SpaceWire standard update

1. See separate presentation:
   a. Presentations (D. Jameux et al.) on technical changes to be included in the new SpW ECSS standard
      – including clarifications and some of the new features discussed earlier
      – based on aggregated Change Requests from the Working Group and related technical discussions
   b. Discussion and possibly agreement on some technical choices
   c. Presentations and discussions interleaved

# 3. SpaceWire 2.0 - Outline

1. Brief presentation of SpW evolutions that belong more to SpaceWire 2.0 that to the standard update
    a. Reliability and Timeliness
    b. Virtual channels
    c. Multicast/Broadcast
    d. Any Other Idea
2. Discussion on the choice of major features follows:




# 3. SpaceWire 2.0 - Introduction

1. Some SpW users (mainly the Working Group) have proposed the introduction of advanced new features into SpaceWire.
2. These features would require major redesign of the protocol stack.
3. They would prevent any form of backward compatibility, even limited.
4. ESA propose that the SpW Working Group address these new features in the frame of the design of SpaceWire 2.0.
5. A number of these features will be briefly presented today (end of the day).

# 3.a Reliability and Timeliness

1. QoS for SpaceWire
2. Allows Timeliness not only for RMAP transactions but for any SpW packets
3. Allows Reliability not only for RMAP transactions but for any SpW packets
4. Allows any combination of Reliability and Timeliness
5. Supports SOIS QoS classes




# 3.b Virtual Channels

1. Virtual Channels
2. Virtual Networks (4Lonks)
   a. Best effort delivery, Reserved QoS, End-to-end flow control

# 3.c Broadcast / Multicast

1. It has been proposed to introduce multicast and/or broadcast capability (with no related technical proposal)

2. Advantage:
   a. Many applications

3. Disadvantage:
   a. Probably implies non backward compatible modifications of the Character Level



# 3.d Any Other Idea ?

## Conclusions (1/2)

1. Introduction
   a. SpaceWire evolutions
   b. Backward compatibility
   c. SpaceWire standard update
   d. SpaceWire 2.0
   e. Study/Breadboarding activities
2. SpaceWire standard update
   a. Presentations (D. Jameux et al.) on technical changes to be included in the new SpW ECSS standard
      – including clarifications and some of the new features discussed earlier
      – based on aggregated Change Requests from the Working Group and related technical discussions
   b. Discussion and agreement on some technical choices
3. SpaceWire 2.0
   a. Brief presentation of SpW evolutions that belong more to SpaceWire 2.0 that to the standard update
   b. Discussion on the choice of major features





## Conclusions (2/2) – Next steps

1. For the next Working Group meeting:
   a. Consolidation of update scope
   b. Consolidation of technical choices
      – Minutes of this meeting
      – Outcome of the ESA studies and breadboarding activities
   c. First draft of the new document
      – In view of issuing a single Change Request to the ECSS board
2. For SpaceWire 2.0
   a. Progress on scope and technical solutions
   b. Based on ESA-funded studies/breadboarding as well as Industry own R&D

# Thank you

# SpaceWire standard update (Session 3 part 2.)

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## Outline

1. Introduction
   a. Input
   b. Categorised change request list
   c. Presentation/Discussion process
2. Technical topics for discussion
3. Conclusion

# Input

1. Many inputs from SpaceWire users (mainly the WG) hinting to some update of the standard:
   a. a number of ambiguities in the ECSS-E-ST-50-12C Standard.
   b. a number of new features to be introduced in SpaceWire.
2. Many forms
   a. ECSS Change Request forms
   b. SpW WG presentations
   c. Support documents to the SpW WG
3. Reformulated in a list of ECSS Change Request forms
   a. Interpretation
   b. Categorisation
   c. Technical discussion by category/theme



# Categorised change request list (1/4)

**1. General**

1.1 Structure of the document

1.2 Alignment with OSI model and general computer networks terminology

1.3 Streamlining references to other standards

**2. Editorial comments**

**3. Physical layer description reduced specification of to electrical signals**

3.1 New shielding and grounding schemes

3.1 Physical channel (cable assembly)

3.2.1 Cables

3.2.2 Connectors

3.3 Backplanes

## Categorised change request list (2 / 4)

**4. Character level (Physical layer) - Data rate**

4.1 Minimum data rate

4.2 Starting data rate

4.3 Maximum data rate

4.4 Data rate negotiation

**5. Update behaviour of nodes & routers**

5.1 Add configuration port in nodes

5.2 Routers shall discard packets with unexpected destination address





## Categorised change request list (3 / 4)

**6. Time-code master: one or more?**

**7. Introduction of backward compatible signalling codes**

7.1 Backward compatibility with Time-codes - Question to the WG

7.2 Interrups+ACK scheme

7.3 General signalling scheme, allowing time codes and interrupts and more

**8. Introduction of simplex and/or half-duplex**

# Categorised change request list (4/4)

**9. Miscellaneous**

9.1 Misleading references to Virtual Channels

9.2 High time-synchronisation resolution option

9.3 Introduce broadcast/multicast

9.4 Requirement on Regional Addressing

9.5 Update state machine

9.6 After reset the time-counter shall be set to zero

9.7 Switching arbitration algorithm

9.8 Router timeout

9.9 State of the link interface during the spilling of a packet

9.10 Over specification of host interface

9.11 Credit count error protection

**10. Inputs to the SpW Handbook**





# Presentation/Discussion process (1/2)

This session is meant to be highly interactive !!

1. For each category or sub-category:
    a. Verbatim of the change requests
        – Feeling of the level of interest
        – Reference if required
    b. Presentation of the issue(s)
    c. Presentation of the aggregated change proposal
        – one or more options
    d. <u>Discussion</u>
    e. Presentation of ESA preferred option (if several)
2. Goal
    a. Short term: The SpW WG to approve <u>today</u> as many dispositions as possible
    b. Medium term: Finalise the scope and technical solutions for the updated SpaceWire; start ECSS standardisation process

# Presentation / Discussion process (2 / 2)

1. Dispositions:
   a. Consolidated Change Request
   b. Change Request
   c. Preliminary Change Request
   d. Open point





# 1.1 Structure of the document – Change requests

| | | | | |
|---|---|---|---|---|
| **0** [Süss] | Whol e docu ment | all | **Revisit the whole document** so that clauses contain only requirements and Notes do not contain any requirement<br>**Remove ambiguities** raised by the SpW users (mainly the Working Group)<br>**Introduce new backward compatible features** raised by the SpW users (mainly the Working Group) | Re-write the standard according to the new ECSS writing rules<br>Ambiguities have lead to different implementations and difficult interoperability of unit/device vendors.<br>These new features are considered necessary for the deployment of SpaceWire networks by the SpaceWire community. |
| **1** [Parkes ECSS-E-ST-50-12C changes.ppt slide 2] | Whol e docu ment | all | **Separate informative and normative material** | |

## 1.1 Structure of the document – Issues (1/2)

SpW users (mainly the Working Group) have detected a number of ambiguities in the ECSS-E-ST-50-12C Standard.

These ambiguities come from

unclear concepts (e.g. SpW nodes)

non-systematic writing rules (clauses and comments are sometimes mixed)

**Advantage:**

A standard document has been published in 2003 and allowed for many devices to be developed with fairly good interoperability

**Disadvantage:**

Ambiguities have lead to different implementations and difficult interoperability of unit/device vendors.





## 1.1 Structure of the document – Issues (2/2)

SpW users (mainly the Working Group) have proposed a number of new features to be introduced in SpaceWire.

The main features are:

configuration port 0 in nodes

signalling codes to carry interrupts across the network

half-duplex and/or simplex links

**Advantage:**

New features validated as useful by the SpW WG

**Disadvantage:**

Risk of limiting interoperability

## 1.1 Structure of the document – Proposed changes to specification

- **Proposed change:** A new revision of ECSS SpaceWire standard
  - Revised scope (removals and additions) and technical choices
  - Written according to new ECSS writing rules
    - Requirement based: each clause shall be a requirement
    - Clear distinction between requirements ("normative") and text ("informative")
- **Benefits:**
  - Better readability
  - Ambiguities removed leading to better interoperability
  - New features validated as useful by the SpW WG
- **Impact:**
  - New features introduce the risk of limiting interoperability




## 1.2 Alignment with OSI model and general computer networks terminology – Change requests (1/2)

| | | | | |
|---|---|---|---|---|
| **2** [Jameux RC 1] | Whole document | all | **Replace all references to routing and routers with switching and switches.** | SpW does not involve routing (OSI layer 3) but only switching (OSI layer 2). |
| **3** [Süss SpaceWire Nodes - June 2010] | 3.2.46 | 19 | **Change definition of node:** according to attached file "SpaceWire Nodes - ISC, Jun 2010, Süss.pdf" | Aligning the definition of nodes to the one of routers to clarify this definition, support PnP, and allow routing in nodes. |
| **4** [Seynin - SpaceWire Standard Evolution.Sheynin.ppt slide 11] | 3.2.46 | 19 | **Clarify definition of node** | Many SpW nodes implementations have more than one link (for fault-tolerance, for throughput improvement, etc.). It isn't covered in the standard, how the links and the node should operate (same/different LA, common/separate time-code register(s), etc.) |

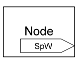
# 1.2 Alignment with OSI model and general computer networks terminology – Change requests (2/2)

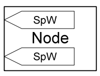
| | | | | |
|---|---|---|---|---|
| **11** [Ferrer - spw new version albert comments.ppt slide 14] | 4.6 | 31 | **Clarify Wormhole routing/switching:** | In literature the term Wormhole switching is widely used as a synonymous of wormhole routing.<br>A reference to this other term could be included. |
| **94** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 10.3 | 100 | **Add routing capability to nodes.** | Whether or not to include the optional routing function described under option C as part of the definition of the SpaceWire node has been controversially discussed during previous SpaceWire working group meetings.<br>For example the draft SpaceWire-PnP Protocol Definition [3] states that nodes are expected to have no routing function: “packets arriving at any port on a node will be consumed by the node.”<br>On the other hand there exist already some devices like the SMCS332SpW (AT7911E) which include such a routing function between the SpaceWire ports of the node. Similar, the Golden Gate ASIC developed by BAE [5], which can be used to connect up to four SpaceWire interfaces through a PCI bus to the host processor, also contains a routing function between the SpaceWire ports. [...] |



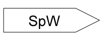
# 1.2.1 Clarify definition of “nodes” – Issues

Many SpaceWire users have identified some ambiguity in the definition of node.

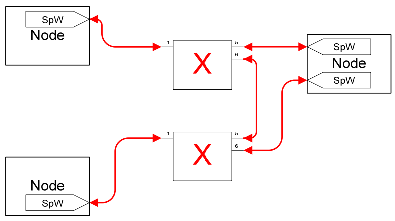
Is a node 

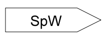
/ 

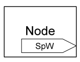
?

Or is it 

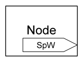
?




In the telecom/computer networks terminology, 

is a “terminal” (terminals and routers/switches are “nodes”, as opposed to links) while 

is not defined since it is not part of the protocol stack.

Note that however SpW-PnP might need the definition of 

## 1.2.1 Clarify definition of "nodes" - Proposed changes to specification

- **Proposed change:** clarify the definition of nodes
  - How to clarify it is still an open point
- **Benefits:**

- **Impact:**

- **Open point:**




## 1.2.2 Add routing capability to nodes – Issues

In the ECSS-E-ST-50-12C Standard, "routers" (switches) can switch packets while "nodes" (terminals) cannot.

**Advantage:**

Complies with OSI model and general computer networks terminology.

**Disadvantage:**

Does not unify routers and nodes

## 1.2.2 Add routing capability to nodes - Proposed changes to specification – Option 1

- **Proposed change:** Add routing capability to nodes
- **Benefits:**
  - Unifies routers and nodes
  - Makes SpW-SMCS and other devices compliant to new standard
- **Impact:**
  - Does not complies with OSI model and general computer networks terminology.
  - Does mix protocol layers

- **Open point:**





## 1.2.2 Add routing capability to nodes - Proposed changes to specification - Option 2

- **Proposed change:** None
- **Benefits:**
  - Complies with OSI model and general computer networks terminology.
  - Does not mix protocol layers
- **Impact:**
  - Does not unify routers and nodes
  - Does not make SpW-SMCS and other devices compliant to new standard

- **Open point:**

## 1.2.2 Add routing capability to nodes - Proposed changes to specification - ESA preferred option

- **Proposed change:** Open point
- **Benefits:**
- **Impact:**
- **Open point:**




## 1.2.3 Protocol description formalism – Issues

The ECSS-E-ST-50-12C Standard

– describes protocol "levels" that are not aligned with OSI

– mixes the description of syntax, synchronisation, semantics, Service Access Points.

**Advantage:**

Facilitates first understanding of the major features of SpaceWire

**Disadvantage:**

Increases the risk of ambiguities when it comes to details

## 1.2.3 Protocol description formalism - Proposed changes to specification – Option 1

• **Proposed change:** Keep as is

• **Benefits:**

- Facilitates first understanding of the major features of SpaceWire

• **Impact:**

- Keeps the risks of ambiguities when it comes to details

• **Open point:**



## 1.2.3 Protocol description formalism - Proposed changes to specification - Option 2

• **Proposed change:** Align protocol description to OSI model and explicitly describe syntax, synchronisation, semantics, and Service Access Points.

• **Benefits:**

- Complies with OSI model and general computer networks terminology.
- Reduces the risks of ambiguities when it comes to details

• **Impact:**

- Major re-writing/reorganisation of the document (will be necessary to comply to ECSS new writing rules)

• **Open point:**

# 1.2.3 Protocol description formalism - Proposed changes to specification - ESA preferred option

- **Proposed change:** Open point
- **Benefits:**
- **Impact:**
- **Open point:**



# 1.3 Streamlining references to other standards – Change requests

| | | | | |
|---|---|---|---|---|
| **5** [Gasti RC 1.1] | 3.2.5 5 | 19 | **Remove section** | The PECL technology is no more used in the manufacturing of LVDS receivers and transceivers. |
| **6** [Gasti RC 1.3] | 4.1 | 24 | **Remove "SpaceWire takes… those differences"** All reference and misleading clarifications to IEEE Standard 1355-1995 shall put in annex. | Section 1 providing the normative reference and section 4.3.2 related to SpW LVDS are referring to ANSI/TIA/EIA-644 and not IEEE Standard 1355-1995. |
| **22** [Gasti RC 1.2] | 5.3.1 a | 38 | **Replace with:** The SpaceWire connectors shall be a nine contact micro-miniature D-type with solder contacts, as ESCC3401/071 or ESCC No. 3401/029 or crimp contacts ESCC reference shall be added for crimp contacts | ESA project are using ESCC No. 3401/029 02B9SFR113E Microminiature MDM Flying leads as there is no qualified nine contact micro-miniature D-type with solder contacts based on ESCC3401/071. Moreover, ESA preferred part list does not include a nine contact micro-miniature D-type with solder contacts based on ESCC3401/071. |

# 1.3 Streamlining references to other standards – Issues (1/4)

The ECSS-E-ST-50-12C Standard refers in a few places (informative) to ECL and PECL

**Advantage:**

*None identified*

**Disadvantage:**

ECL and PECL are not used for on-board data systems nor for ground applications; misleading



# 1.3 Streamlining references to other standards – Issues (2/4)

The ECSS-E-ST-50-12C Standard refers in a few places (informative) to 1355-1995 as the source of LVDS specification although section 1 providing the normative reference and section 4.3.2 related to SpW LVDS are referring to ANSI/TIA/EIA-644 and not IEEE Standard 1355-1995.

**Advantage:**

Tribute to 1355

**Disadvantage:**

Confusing

The reference to the LVDS specification should be unique and unambiguous.

# 1.3 Streamlining references to other standards – Issues (3/4)

The ECSS-E-ST-50-12C Standard refers to section 5.3.5 of IEEE Standard 1355-1995 for the specification of the Data-Strobe encoding.

**Advantage:**

Avoids referring explicitly to the STM patents

**Disadvantage:**

Confusing

The reference to DS encoding specification should be unique and unambiguous.



# 1.3 Streamlining references to other standards – Issues (4/4)

The ECSS-E-ST-50-12C Standard specifies that SpaceWire connectors shall be a nine contact micro-miniature D-type with solder contacts, as ESCC3401/071 or crimp contacts.

**Advantage:**

ESCC3401/071: ensure high quality soldering

**Disadvantage:**

ESA project are using ESCC No. 3401/029 02B9SFR113E Microminiature MDM Flying leads as there is no qualified nine contact micro-miniature D-type with solder contacts based on ESCC3401/071.

Moreover, ESA preferred part list does not include a nine contact micro-miniature D-type with solder contacts based on ESCC3401/071.

# 1.3 Streamlining references to other standards – Proposed changes to specification (1/2)

- **Proposed change:**
  - Remove references to ECL and PECL
  - Remove references to 1355-1995 except in the introduction/history section
  - Add references to the STM patents for DS encoding
- **Benefits:**
  - Increase readability
  - Remove ambiguities of references





# 1.3 Streamlining references to other standards – Proposed changes to specification (2/2)

- **Proposed changes:**
  - The ECSS-E-ST-50-12C Standard should specify that SpaceWire connectors shall be a nine contact micro-miniature D-type with solder contacts, as ESCC3401/071 or ESCC No. 3401/029 or crimp contacts
  - ESCC reference should be added for crimp contacts.
- **Benefits:**
  - Comply with ESA preferred part list
  - Provide specification for crimp contacts

This issue might disappear if the new standard does not specify manufacturing processes anymore.

# 2. Editorial comments – Change requests (1 / 4)

| | | | | |
|---|---|---|---|---|
| **8** [Bonnet RC1.1] | Figure 4-1 | 26 | **Correct figure**<br>[voltage values are wrong] | Indeed, if the voltage across the input resistor of 100 Ohm is 350mV, then the voltage indicated on the right of the arrows are wrong.<br>I think it is not +250mV +400mV typical but +125mV +200mV typical.<br>There is a ratio 2 between both values. |
| **9** [Ilstad – comment p26 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI.pdf] | Figure 4-1 | 26 | **Do NOT correct figure** | Actually this figure is correct and in line with EIA/TIA-644 specification. The figure indicates the minimum voltage threshold a receiver must adhere to to change state. if the differential signal is less than +/- 100mV then behaviour of the receiver is not guaranteed. |
| **42** [Ferrer - spw new version albert comments.ppt slide 3] | Figure 6-2 | 48 | **Replace figure with the one attached here.** | |
| **43** [Isomaki RC5.3] | 7.2 | 52 | **Add specification in text** that parity is sent first, then control bit and lastly data starting from the LSB | Currently it is only indicated in the figure with an arrow in what order the characters are transmitted. Only the data bit transmission order is explicitly specified in the text. |
| **50** [Isomaki RC5.4] | Figure 7-2 | 53 | **An explicit requirement should refer to the figures** as the definition of the characters. Also the transmission order of the bits should be explicitly stated. | Currently the figure is only referenced from a NOTE which is not according to ECSS standardization rules. |



# 2. Editorial comments – Change requests (2 / 4)

| | | | | |
|---|---|---|---|---|
| **57** [Isomaki RC6.1] | 7.4a | 54 | **Remove.** | It is already specified for both data characters and control characters in clauses 7.2 and 7.3 where a parity bit should be included. This clause should only specify how it is used. |
| **59** [Isomaki RC5.2] | 7.7d | 56 | **Remove** | Specified in 8.12.2 since only one node or router is allowed to be time-master. It is not appropriate to have time distribution specifications in this section as it should only specify the signal interface. |
| **68** [Nomachi - SpaceWire-modification_request.v1 - Masaharu Nomachi.ppt slide 2] | 8.11.2 | | **Change:**<br>[The definition for duration (727-1000ns) should be clarified..] | [see also figure attached] |
| **72** [Isomaki RC1.4] | 8.12.2e | | **Remove** | Specified in 8.3 m, n. |

# 2. Editorial comments – Change requests (3 / 4)

| | | | | |
|---|---|---|---|---|
| **73** [Isomaki RC2.1] | 8.12. 2f | 84 | **Remove** | This clause is actually not as clear as it seems. It specifies that a time-master entity shall not try to transmit a time-code unless it has first checked that the link interface in question is in the run-state. Nowhere is a requirement written that says that a transmitter shall only transmit time-codes in the run-state. Clauses 8.3 p,q, r and s have some requirements. 8.4.2 on page 60 also have some relevant text but it is descriptive. 8.5.2.7 a states what is actually needed as a requirement but only as a NOTE which is thus descriptive. The part in the NOTE should be made an explicit requirement and this clause (8.12.2 f) should be removed. |
| **74** [Isomaki RC2.2] | 8.12. 2g84 | | **Replace with the following:**<br>When a Time-code is received on a node or router the following shall be done:<br>1. Compare the time-count value of the time-code with the local time-counter.<br>2. If the time-count value of the Time-code is one more modulo 64 than the current time-counter value the time-counter is updated and the updated value is transmitted on all link interfaces except the one it was received on.<br>3. If the time-count value of the Time-code is equal to the current time-counter value nothing is done.<br>If the time-count value of the Time-code is neither one more modulo 64 nor equal to the time-counter value the time-counter should be updated with the received value. | Previously the information in this replacement clause was spread out into several other clauses. I specify why these clauses should be removed and replaced with this one in the removal change requests for those clauses. It should also be specified explicitly that the calculations are done modulo 64. It is also specified that the node or router should send the time-code to all the ports except the one it was received on. The node or router at the originating port should already be updated but this is not a necessary requirement since even if the time-code is transmitted on the originating port it will not be propagated. This requirement could therefore perhaps be removed to ease implementation. The downside is that an unnecessary time-code is transmitted. |





# 2. Editorial comments – Change requests (4 / 4)

| | | | | |
|---|---|---|---|---|
| **75** [Isomaki RC2.3] | 8.12. 2h | 84 | **Remove** | It is sufficient to state that it shall be checked that the time-count is one more than the time-counter value which is done in other clauses. This clause does not add any information. |
| **76** [Isomaki RC2.4] | 8.12. 2i | 84 | **Remove in favour of new 8.12.2.g** | As it is now it is not verifiable on its own since it specifies a situation when the procedure in the current 8.12.2 g does not apply. |
| **77** [Isomaki RC3.2] | 8.12. 2j | 84 | **Remove in favour of new 8.12.2.g** | This clause is not individually verifiable since it violates the procedure specified in the current 8.12.2 g. The relevant information from this clause is included in the new clause 8.12.2 g. |
| **78** [Isomaki RC3.2] | 8.12. 2k | 84 | **Remove in favour of new 8.12.2.g** | This clause is not individually verifiable since it violates the procedure specified in the current 8.12.2 g. |
| **79** [Isomaki RC3.3] | 8.12. 2l | 85 | **Remove in favour of new 8.12.2.g** | This clause is not individually verifiable since it violates the procedure specified in the current 8.12.2 g. |

## 2. Editorial comments – Issues

A number of the editorial change requests deal with issues that might be revisited (e.g. Time-Codes and their handling) so there is no point addressing them at this stage.

Most of the editorial change requests are not controversial so their do not require technical any debate.




## 2. Editorial comments – Proposed changes to specification

- **Proposed change:** **Postpone processing of these change requests until major technical issues have been agreed**
- **Benefits:**
    - **More efficient standard update process**

# 3. Physical layer description reduced to specification of electrical signals

3.1 New shielding and grounding schemes

3.2 Physical channel (cable assembly)

3.2.1 Cables

3.2.2 Connectors

3.3 Backplanes





# 3.1 New shielding and grounding schemes – Change requests (1/4)

| | | | | |
|---|---|---|---|---|
| **23** DS - 23 sept. 10 14:42 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.3.4 | 39 | Pin 3 is useless | |
| **24** DS - 23 sept. 10 14:44 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.3.5 | 40 | 5.3.5 Individual shield connection<br>Each twisted pair shield shall be connected to the connector backshell over 360°. The backshell shall be a fully closed metallic enclosure.<br>The rest of this paragraph is unjustified and should be removed. | |
| **25** [Ilstad – comment p40 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI.pdf] | 5.3.5 b&c | 40 | Both 5.3.5 b. and c. should be adapted depending on recommendation outcomes from the Low Mass SpaceWire activity. | Point c. is in not correctly specified. If a connection via resitor and capacitor is to be used, then it should be done at the opposite end of the inner shield connection (pin3). As it is written here it can be misunderstood that the connection from pin3 to inner shield should go via resistor and capacitor - a useless thing to do. |

# 3.1 New shielding and grounding schemes – Change requests (2/4)

| | | | | |
|---|---|---|---|---|
| **26** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 5.4 | 41 | **Change:**<br>[A connection of the inner shield on both sides with the possibility to implement a controlled capacitive decoupling on one side behind the plug could be investigated as a solution.] | The micro-miniature D-type connector has nine signal contacts. Eight are used for the 4 twisted pair cables and one is used to terminate the inner shields at end of the cable from which the signals are being driven. The inner shields are isolated from one another. This feature can be useful to prevent loops in the grounding design and the symmetrical arrangement avoids the problem of having to know which end of the cable is which during installation.<br>A problem occurs when the cable is broken into several parts due to bulk head connectors which are often used in larger structures. This leads to the situation that the inner shields on both sides of the bulkhead are not connected to the ground of either side. |
| **27** [Ilstad – comment p41 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI.pdf] | 5.4 | 41 | Final recommendation pending results from Low Mass SpaceWire activity. | |





# 3.1 New shielding and grounding schemes – Change requests (3/4)

| | | | | |
|---|---|---|---|---|
| **28** DS - 23 sept. 10 14:53 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.4.3 | 41 | The whole paragraph should fit with the new implementation:<br>- individual shielded twisted pairs<br>- shields 360° terminated in the metallic backshell. | |
| **29** DS - 23 sept. 10 14:57 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.4.3 d&e | 41 | d. Shields bonded via <10mΩ impedance connection<br>e. Backshell to main body via <10mΩ impedance connection | |
| **30** [Ilstad – comment p42 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI.pdf] | Figure 5-3 | 42 | Inner shield grounding scheme is due for revision. Recommendations pending results from Low Mass SpaceWire activity. | |

# 3.1 New shielding and grounding schemes – Change requests (4/4)

| | | | | |
|---|---|---|---|---|
| **31** DS - 23 sept. 10 15:01 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | Figure 5-3 | 42 | To be redrawn | - no more ground pin<br>- shields connected to the main body via a backshell free of aperture. |




# 3.1 New shielding and grounding schemes – Issues

The ECSS-E-ST-50-12C Standard specifies that inner shields connected to transmit end only.

**Advantage:**

Simple and symmetric scheme

**Disadvantages:**

Provided electrostatic screen - inefficient at higher frequencies >1MHz; SpaceWire operates at much higher frequencies up to 100MHz data rate, fast signal edges (~1ns R/F times).

Does not allow SpW cable extension (e.g. board-to-box, box-to-box, box to board)

# 3.1 New shielding and grounding schemes – Proposed changes to specification

- Proposed changes: **change connection of inner shields**
  - Low impedance bond at both ends to connector back shell / chassis
  - Leave pin 3 unconnected.
  - A drain wire could potentially be used (TBC)
- With view towards a change of cable specification
  - Not all applications need double shielded SpaceWire cable.
- Selection of Cable depend on
  - Mission EMI / EMC requirements
  - Space Craft grounding scheme.
- Benefits:
  - Improve the EMC protection in the 100MHz range
  - Allow SpW cable extension (e.g. board-to-box, box-to-box, box to board)

These are preliminary recommendations. More consolidated proposal will follow the outcome of currently running ESA R&D activities including breadboarding



# 3.2 Physical channel (cable assembly)

3.2 Physical channel (cable assembly)

3.2.1 Cables

3.2.2 Connectors

# 3.2 Physical channel (cable assembly) – Change requests

| | | | | |
|---|---|---|---|---|
| **39** [Parkes ECSS-E-ST-50-12C changes.ppt slide 18] | 6.6.4 | 46 | **Change:**<br>Define skew and jitter in terms of acceptable eye pattern at receiver | |
| **40** DS - 23 sept. 10 15:36 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 6.6.4.1 | 47 | | EMC/EMI:<br>The skew generates a comb of nearly constant emission lines from the frequency bit rate up to about 1GHz and then very aggressive in term of EMI.<br>This is particularly a problem when LVDS signals cover a long distance inside a unit. Low frequency bit rates are even more aggressive because of the increase of the frequency overlap with low-level signals. |



# 3.2.1 Cables – Change requests (1/6)

| | | | | |
|---|---|---|---|---|
| **12** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 5.2 | 33 | **Re-write paragraph:**<br>specify not the construction but some physical and electrical parameters. These could comprise parameters like Differential Impedance, Signal Skew, Return Loss, Insertion Loss, Near-end Crosstalk (NEXT) and Far-end Crosstalk (FEXT) | The standard provides a very detailed and rigid specification on the construction of the cable. It specifies e.g. wire type and size of the conductors but also of the shield, filler, binder and jacket material. This kind of specification can be directly given to a cable manufacturer who can based on this produce a cable compliant to the standard, which is able to transmit the signal over a length of 10 m and support a data rate of 200 Mbps. The disadvantage is that this cable may be too heavy and rigid for some short connections and too lossy for distances beyond 10 m. Some different cable constructions have been proposed in the past. |
| **13** [Parkes ECSS-E-ST-50-12C changes.ppt slides 3-11] | 5.2 | 33 | **Change cable and cable assembly:**<br>Remove inner shields<br>- May be a cross-talk issue<br>Connect inner shields together and to outer shield<br>- Will reduce stiffness, size and weight<br>- Will not degrade electrical performance<br>Include drain wire<br>Connect to pin 3 at both ends<br>- Prevents “bulk-head” problem<br>- Simplifies and improves grounding arrangement | Connect to ground at one end only<br>Provides a ground reference for differential pair<br>100 Mbit/s signals<br>1 ns edges<br>1 GHz signals<br>Inner shield effective for around 150 mm |

# 3.2.1 Cables – Change requests (2/6)

| | | | | |
|---|---|---|---|---|
| **14** [Ilstad – comment p33 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI.pdf] | 5.2 | 33 | | With regards to the SpaceWire Cable construction, a draft standardisation text for SpaceWire WG evaluation will be one of the outputs from the ongoing Low Mass SpaceWire cable activity. At present several alternative cable constructions are being evaluated in addition to alternative connectors for the cable assembly. As mentioned above in the comment, section 5.2 should rather specify electrical parameters than the cable construction itself to allow more freedom for different constructions to be applied according to user needs. The downside of this approach may be that a range of cables needs qualification which can be a costly and lengthy procedure.<br>At present a one of the solutions that seems most appropriate is to remove the outer shield while terminating inner shields at both ends to chassis. Pin 3 is then left unconnected at both sides as the electronics inside a box is also grounded to chassis to follow good EMC rules. |



# 3.2.1 Cables – Change requests (3/6)

| | | | | |
|---|---|---|---|---|
| **33** DS - 23 sept. 10 15:21 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.5.2 | 43<br>1<br>a | | For transmitted bit rates much lower than 200Mb/sec, the LVDS frequency bandwidth can be limited using a pair of capacitive load at the transmitter output terminals. This method is particularly useful to reduce EMI on low-level signals within a unit. |
| **15** [Nomachi - SpaceWire-modification_request.v1 - Masaharu Nomachi.ppt slide 2] | 5.2.2 | 34<br>1<br>a | **Remove.** | Thick signal wire such as 24 AWG is required for launch vehicle application. |

# 3.2.1 Cables – Change requests (4 / 6)

| | | | | |
|---|---|---|---|---|
| **16** [Nomachi - SpaceWire-modification_request.v1 - Masaharu Nomachi.ppt slide 2] | 5.2.1 | 34 | **Remove.** | Thick signal wire such as 24 AWG is required for launch vehicle application. |
| **17** [Ilstad – comment p36 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI.pdf] | 5.2.4 | 36 | This section should be considered removed. | If electrical performance parameters, including EMC/EMI levels, are specified that cables must adhere to, then cables can be constructed in various ways depending on length, data rate and slew rate of the driver or particular environmental requirements. |





# 3.2.1 Cables – Change requests (5 / 6)

| | | | | |
|---|---|---|---|---|
| **18** DS - 23 sept. 10 14:38 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.2.4 | 37 | Could be used for the shielding introduction then a. should talk about 4 individually screened twisted pairs. | Outer shield No more needed. |
| **19** DS - 23 sept. 10 14:39 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.2.4 | 37 | To be removed. | Unjustified |

# 3.2.1 Cables – Change requests (6 / 6)

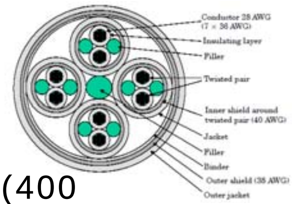
| | | | | |
|---|---|---|---|---|
| **20** [Parkes ECSS-E-ST-50-12C changes.ppt slides 12-14] | 5.2.4 | 34<br>1<br>5 | **Change:**<br>Make cable signal skew specification much tighter<br>E.g. Factor of 5<br>- 0.02 ns per m<br>- 150 mm per ns<br>- 3mm length difference per m of cable | <u>Cable attenuation</u><br>Include larger wire gauge cores for reduced attenuation<br>i.e. have a least two different cables<br>Larger, heavier long distance (20 m)<br>E.g. 26 AWG<br>Smaller, lighter short distance (5 m)<br>E.g. 28 AWG or 30 AWG?<br><u>Higher Speed SpaceWire</u><br>400 Mbits/s plus<br>Principal limitation is connector impedance mismatch<br>(and cable attenuation)<br>Need connector with 100 ohm differential impedance up to 2 or 3 Gbps |



# 3.2.1 Cables – Issues

The ECSS-E-ST-50-12C Standard gives detailed specification on the construction of the SpaceWire cable

**Advantages:**




– Specification can be delivered directly to a manufacturer to produce a compliant cable.

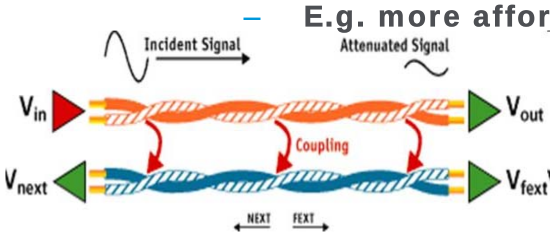
– The specified cable was tested for high data rate (400 Mbps), high EMC and high radiation environment and can therefore suit most ground and space needs <u>in this respect</u>.

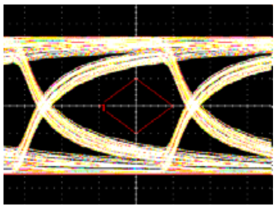
**Disadvantages:**

The cable may be **heavier** and more **rigid** than necessary for shorter cable lengths or for lower radiation environment or for lower data rates.

# 3.2.1 Cables - Proposed changes to specification – option 1 (1/2)

- **<u>Proposed change:</u>** Specify <u>electrical (not mechanical)</u> parameters verifiable by measurement rather than detailed cable construction.
- **<u>Benefits:</u>**
    - Allows for improvement of SpaceWire cable mechanical properties while keeping the electrical parameters standardised
        - E.g. lower mass cables
        - E.g. more flexible cables
        - E.g. more affordable cables





# 3.2.1 Cables - Proposed changes to specification – option 1 (2/2)

- **<u>Benefits (cont'd):</u>**
    - The resulting cables are expected to cope with high data rate (400 Mbps), high EMC and high radiation environment and will therefore suit most ground and space needs in this respect.
- **<u>Impact:</u>**
    - The quality of each cable will still have to be tested for space missions (specification is not enough).
    - Mechanical improvements will be limited by high quality electrical requirements.
    - May lab cables and some flight cable will deviate form the standard.

## 3.2.1 Cables - Proposed changes to specification – Note

- The ECSS standard on 1553 bus only addresses higher layers of the protocol, relying on MIL-1553B standard for the lower layers but the MIL-1553B standard does specify properties of the electrical signals, not cables.
- The ECSS standard on CAN does also specify properties of the electrical signals, not cables.
- The ECSS standard on Discrete Interfaces does also specify properties of the electrical signals, not cables.
- For ground applications, various qualities of USB or HDMI cables are available to suit the needs of various users. Ethernet can be carried on low-cost cables like Unshielded Twisted Pair (UTP) or higher-cost ones like Shielded Twisted Pair (STP or STP-A), Screened unshielded twisted pair (S/UTP) also known as Foiled Twisted Pair (FTP), Screened Shielded Twisted Pair (S/STP or S/FTP), etc. depending on the quality required (e.g. Gbit Ethernet).



## 3.2.1 Cables - Proposed changes to specification – option 2 (1/2)

- Proposed change: Not to specify any cable.
- Benefits:
  - Allows for different SpaceWire cables fulfilling different requirements
    - E.g. wide-range-of-mass cables (on-board, lab)
    - E.g. wide-range-of-flexibility cables (different on-board configurations, lab)
    - E.g. wide-range-of-price cables (on-board, lab)
  - Allows for improvement of SpaceWire cable mechanical properties for the same electrical parameters (identical as option 1)

# 3.2.1 Cables - Proposed changes to specification – option 2 (2/2)

- **Proposed change:** Provide the specification of several cables in the SpW Handbook or as an annex.
- **Benefits:**
  - Allows users to quickly procure cables for non-specified SpaceWire links
  - **Reduces** cable screening process at mission level





# 3.2 Connectors – Change requests

| | | | | |
|---|---|---|---|---|
| **21** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 5.3 | 38 | **Insert:**<br>[additional connector types should be included in the standard?] | A nine-pin micro-miniature D-type is specified as the SpaceWire connector. It is compact and available for space use. The differential impedance of the D-type connectors does not match the 100 Ω of the cables and the termination. Still in practice the distortion introduced by it is acceptable in most cases. Other connectors like a 4-way twinax connector [2][3][4] or circular 13 pin 38999 Series II connector [6] have been proposed and investigated. |

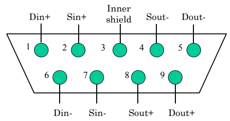
## 3.2.2 Connectors – Issues

The ECSS-E-ST-50-12C Standard gives detailed specification on the SpaceWire connector

**Advantages:**

Mechanical and pin allocation enforced compatibility allows for interoperability.

Electrical properties of the chosen connector allow for up to 400 Mbps data rate.



Viewed from rear of receptacle or front of plug

**Disadvantages:**

The connector may be **heavier** and more **bulky** than necessary for some missions; it may be **too fragile** for others.

Bulkhead connectors are not allowed.





## 3.2.2 Connectors - Proposed changes to specification – Option 1

- **Proposed change:** **Specify only the type, pin allocation and electrical properties of the connector.**
- **Benefits:**
  - **Keeps forced interoperability at mating level**
  - **Allows for improvement of SpaceWire connector mechanical properties (other than shape and pin allocation) for the same electrical parameters**
- **Disadvantages:**
  - **Potential for mechanical improvement is very limited so the connector may still be heavier and more bulky than necessary for some missions; it still may be too fragile for others.**
  - **Bulkhead connectors are still not allowed.**
  - **Many space missions will deviate form the standard.**

# 3.2.2 Connectors - Proposed changes to specification – Note

- The ECSS standard on 1553 bus only addresses higher layers of the protocol, relying on MIL-1553B standard for the lower layers but the MIL-1553B standard does specify properties of the electrical signals, not connectors.
- The ECSS standard on CAN does also specify properties of the electrical signals, not connectors.
- The ECSS standard on Discrete Interfaces does also specify properties of the electrical signals, not connectors.
- For ground applications, various forms and qualities of USB or HDMI cables are available to suit the needs of various users.

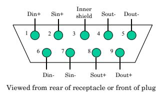


# 3.2.2 Connectors - Proposed changes to specification – Option 2 (1/2)

- Proposed change: Not to specify any connector.
- Benefits:
  - Allows for different SpaceWire connectors adapted to different cables and fulfilling different requirements
    - E.g. wide-range-of-mass connectors (on-board, lab)
    - E.g. wide-range-of-flexibility connectors (different on-board configurations or stress levels, bulkhead, lab)
    - E.g. wide-range-of-price connectors (on-board, lab)
  - Allows for improvement of SpaceWire connector mechanical properties for the same electrical parameters
  - Allows for improvement of SpaceWire connector electrical properties for the same shape and pin allocation

# 3.2.2 Connectors - Proposed changes to specification – Option 2 (2/2)

1. <u>Proposed change:</u> Provide the specification of several connectors (these shall obviously include the current SpW connector) and provide guidelines (e.g. impedance matched to allow for higher signalling rate) in the SpW Handbook or as an annex



2. <u>Benefits:</u>
   a. Allows users to quickly procure cables assemblies for non-specified SpaceWire links
   b. Allows skipping connector screening process at mission level
3. One example would be a Twinax assembly
4. In addition miniaturised connectors such as nano-d may considered as suitable alterative connector -> serve e.g. rover missions such as Exomars.

Twinax Assembly for SpW (GORE)

Nano-D connectors (Axon Cable)



# 3.2 Physical channel - Proposed changes to specification – ESA preferred option

- **<u>Proposed change:</u> Specify only the type and pin allocation of the connector; and electrical properties of the cable assembly.**
- **<u>Benefits:</u>**
  - **Keeps forced interoperability at mating level**
  - **The resulting cable assemblies are expected to cope with high data rate (400 Mbps), high EMC and high radiation environment and will therefore suit most ground and space needs in this respect.**
  - **Allows for improvement of SpaceWire cable assembly mechanical properties (other than shape and pin allocation) for the same electrical parameters**
- **<u>Impact:</u>**
  - **Potential for mechanical improvement is very limited so the cable assembly may still be heavier and more bulky than necessary for some missions; it still may be too fragile for others.**
  - **Bulkhead connectors are still not allowed.**
  - **The quality of each cable assembly will still have to be tested for space missions (specification is not enough).**
  - **Many space missions will deviate form the standard.**

## 3.3 Backplanes – Change requests

| | | | | |
|---|---|---|---|---|
| **32** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 5.5 | 43 | **Insert:** [Add requirements on backplane connectors or backplane construction.] | SpaceWire links are often used within a unit or electronic box. The current SpaceWire standard contains some requirements on PCB and backplane tracking but no requirements on backplane connectors or backplane construction. |



## 3.3 Backplanes – Issues

The ECSS-E-ST-50-12C Standard provides very little requirements on PCB and backplane tracks. It does not specify inter-PCB connectors.

**Advantages:**

Freedom of implementation allows adapting to specific mechanical constraints

**Disadvantages:**

Lack of specification has lead to performance issues.

Different implementations will also result in difficult interoperability of unit/device vendors.

## 3.3 Backplanes - Proposed changes to specification – Option 1

- **Proposed change:** Specify the type and pin allocation of PCB connectors; and electrical properties of the PCB-to-PCB "cable" assembly.
- **Benefits:**
  - Keeps forced interoperability at mating level
  - The resulting PCB-to-PCB "cable" assemblies are expected to cope with high data rate (400 Mbps), high EMC and high radiation environment and will therefore suit most ground and space needs in this respect.
  - Allows for improvement of SpaceWire PCB-to-PCB "cable" assembly mechanical properties (other than shape and pin allocation) for the same electrical parameters
- **Impact:**
  - Potential for mechanical improvement is very limited so the cable assembly may still be heavier and more bulky than necessary for some missions; it still may be too fragile for others.
  - The quality of each PCB-to-PCB "cable" assembly will still have to be tested for space missions (specification is not enough).
  - Many space missions will deviate form the standard.



## 3.3 Backplanes - Proposed changes to specification – Option 2

- **Proposed change:** Remove any requirement regarding backplanes but document backplane-related hints and advice in the Handbook.
- **Benefits:**
  - Allows for improvement of SpaceWire backplane mechanical properties for the same electrical parameters
  - Allows for different SpaceWire backplane technologies adapted to different units and fulfilling different requirements
    - E.g. FLEX (flexible board) for PCB-to-PCB SpW links
    - E.g. use of multi-layer boards

## 3.3 Backplanes - Proposed changes to specification – ESA preferred option

- **Proposed change:** **Specify the type and pin allocation of PCB connectors; and electrical properties of the PCB-to-PCB "cable" assembly.**
- **Benefits:**
  - **Keeps forced interoperability at mating level**
  - **The resulting PCB-to-PCB "cable" assemblies are expected to cope with high data rate (400 Mbps), high EMC and high radiation environment and will therefore suit most ground and space needs in this respect.**
  - **Allows for improvement of SpaceWire PCB-to-PCB "cable" assembly mechanical properties (other than shape and pin allocation) for the same electrical parameters**
- **Impact:**
  - **Potential for mechanical improvement is very limited so the cable assembly may still be heavier and more bulky than necessary for some missions; it still may be too fragile for others.**
  - **The quality of each PCB-to-PCB "cable" assembly will still have to be tested for space missions (specification is not enough).**
  - **Many space missions will deviate form the standard.**

This is the preliminary ESA position. Final ESA position will specify physical channel and inter-PCB connector (following outcome of studies) and will be proposed only if it does not delay the update of the standard



## 4 Character level (Physical layer) - Data rate

4.1 Minimum data rate

4.2 Starting data rate

4.3 Maximum data rate

4.4 Data rate negotiation

# 4.1 Minimum data rate – Change requests

| | | | |
|---|---|---|---|
| **36** [Parkes ECSS-E-ST-50-12C changes.ppt slide 16] | 6.6.1 | 46 | **Change:**<br>Increase minimum data rate to 4 Mbits/s<br>Allows time for both ends to respond to speed change<br>Possible extension to low data rate start-up<br>E.g. 1 Mbits/s or 2 Mbit/s<br>Required modification to state machine time-out times |





# 4.1 Minimum data rate – Issues

The ECSS-E-ST-50-12C Standard specifies the minimum data rate as 2Mbps (physical limitation being 1.18Mbps)

**Advantages:**

Allows for low power communication.

Allows for low EMC creation.

**Disadvantage:**

Implementations experience difficulties to comply, specially when from 10Mbps to 2Mbps (limiting min to 4Mbps would help).

# 4.1 Minimum data rate - Proposed changes to specification

- **Proposed change:** Keep 2Mbps (links do not have to switch directly from 10Mbps to 2Mbps)
- **Benefits:**
  - Backward compatibility
  - Allows for low power communication.
  - Allows for low EMC creation.

ESA position could be reconsidered if a majority of the WG supports the change.



# 4.2 Starting data rate – Change requests

| | | | | |
|---|---|---|---|---|
| **41** [Seynin - SpaceWire Standard Evolution.Sheynin.ppt slide 6] | 6.6.5 | 47 | **Change:**<br>We restart a link at its regular rate at once. | When the link is running at regular rate of hundreds of Mb/s, to restart the link starting at 10 Mb/s after every detected error and then moving to the regular for this link rate causes unreasonable delays, gaps in information flow. |

# 4.2 Starting data rate – Issues

The ECSS-E-ST-50-12C Standard specifies the starting data rate as (10+/-1)Mbps

**Advantages:**

Provide all systems with a common, slow, initial data signalling rate so that system operation can be validated before switching to higher and possibly widely different data signalling rates.

**Disadvantages:**

Prevents implementing low data-rate-only interfaces (<10 Mbps) e.g. slow-clocked very-low-power interfaces

When the link is running at regular rate of hundreds of Mb/s, to restart the link starting at 10 Mb/s after every detected error and then moving to the regular for this link rate causes unreasonable delays, gaps in information flow.



# 4.2 Starting data rate - Proposed changes to specification – Option 1

- **Proposed change:** **Keep 10Mbps**
- **Benefits:**
  - **Backward compatibility**
  - **Provide all systems with a common, slow, initial data signalling rate so that system operation can be validated before switching to higher and possibly widely different data signalling rates**

ESA position could be reconsidered if a majority of the WG supports the change.

## 4.2 Starting data rate - Proposed changes to specification – Option 2

- **Proposed change:** Do not specify any starting data rate (smart vendors will most likely offer some step-by-step downwards connection attempting scheme; to be added in the SpW Handbook)
- **Benefits:**
  - Smart systems will implement a common, slow, initial data signalling rate
  - Allows implementing low data-rate-only interfaces (<10 Mbps) e.g. slow-clocked very-low-power interfaces
  - Allows restating a link at maximum data rate in order to minimise delays, gaps in information flow.




## 4.2 Starting data rate - Proposed changes to specification – ESA preferred option

- **Proposed change:** Keep 10Mbps
- **Benefits:**
  - Backward compatibility
  - Provide all systems with a common, slow, initial data signalling rate so that system operation can be validated before switching to higher and possibly widely different data signalling rates

ESA position could be reconsidered if a majority of the WG supports the change.

# 4.3 Maximum data rate – Change requests

| | | | |
|---|---|---|---|
| **37** [Parkes ECSS-E-ST-50-12C changes.ppt slide 17] | 6.6.2 | 46 | **Change:**<br>Define maximum data rate to be 200 Mbits/s using existing specified cables and connectors |





# 4.3 Maximum data rate – Issues

The ECSS-E-ST-50-12C Standard does not specify the maximum data rate

**Advantages:**

Allows for maximum data rate that implementations can achieve.

**Disadvantages:**

None

## 4.3 Maximum data rate - Proposed changes to specification

- **Proposed change:** Keep it as it is, removing the clause "a.The maximum data signalling rate shall be defined." because it does not bring any benefit
- **Benefits:**
  - Allows for maximum data rate that implementations can achieve.





## 4.4 Negotiating data rate – Change requests

| | | | | |
|---|---|---|---|---|
| **38** [Seynin - SpaceWire Standard Evolution.Sheynin.ppt slide 6] | 6.6.3 | 46 | **Change:**<br>Introduce two-side procedure to agree on rates. | duplex link rate matching procedure by negotiation and/or by sequence of attempts is required.SpaceWire is a standard with smooth, continuous rates scale and lack of a two-side procedure to agree on rates looks as a flaw in the standard |

## 4.4 Negotiating data rate – Issues

The ECSS-E-ST-50-12C Standard does not provide any mechanism for data rate negotiation

**Advantages:**

Keeps the protocol simple.

**Disadvantages:**

Does not provide any mechanism for data rate negotiation.





## 4.4 Negotiating data rate - Proposed changes to specification

- **Proposed change:** **Keep it as it is, describing in the Handbook that data rate negotiation can be done at application level and may be included in SpW PnP.**
- **Benefits:**
  - **Keeps the protocol simple**
  - **Backward compatibility**

# 5. Update behaviour of nodes & routers

5.1 Add configuration port in nodes

5.2 Routers shall discard packets with unexpected destination address





# 5.1 Add configuration port in nodes – Change requests

| | | | | |
|---|---|---|---|---|
| **95** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 10.3 | 100 | **Add configuration port in nodes.** | Every SpaceWire routing switch has one internal configuration port with address zero. It can be used to configure the routing switch and to obtain status information. This is an important feature for network discovery and PnP. It showed to be a problem that this port zero is only present in routing switches and not in nodes. The update of the definition will align the SpaceWire Node addressing with the SpaceWire Routing Switch addressing. An internal configuration port with address 0 will be introduced for nodes but normal SpaceWire packets starting with a logical address (32 – 254) will be passed to the next layer as before.<br>With the described modification, the concept of node is tied to a single configuration<br>port which can be accessed from all SpaceWire links which belong to this node. In this port zero configuration space, among others, information about all links belonging to the node can be found. [...] |

# 5.1 Add configuration port in nodes – Issues

The ECSS-E-ST-50-12C Standard foresees a configuration port (address 0) for routers but not for nodes

**Advantages:**

Keeps the point-to-point protocol simple (possibly no header).

**Disadvantages:**

Does not allow for interface configuration through the link (implemented in SMCS devices via custom protocol)

Does not allow for automatic discovery of nodes




# 5.1 Add configuration port in nodes - Proposed changes to specification

- **Proposed change:** **Introduce configuration port 0 for nodes**
- **Benefits:**
  - **Allows for interface configuration through the link (implemented in SMCS devices via custom protocol)**
  - **Allows for automatic discovery of nodes**
- **Impact:**
  - **The leading logical address must be made mandatory, as in the PID protocol (ECSS-E-ST-50-51C)**
  - **Forbid logical address mapping to port 0 in routers (already in ECSS-E-ST-50-12C ?)**
- **Open point:**
  - **Should we include the whole PID into the SPW standard?**

# 5.2 Routers shall discard packets with unexpected destination address – Change requests

| | | | | |
|---|---|---|---|---|
| **98** [Parkes ECSS-E-ST-50-12C changes.ppt slide 21] | 11.3.4 | 108 | **Change**<br>[Packet with unexpected destination address shall be discarded]<br>**with**<br>[Packet with unexpected destination address can be discarded] | Conflict with RMAP which responds to invalid addresses |





# 5.2 Routers shall discard packets with unexpected destination address – Issues

In the ECSS-E-ST-50-12C Standard does NOT specify that nodes shall discard packets with unexpected destination address but DOES specify that routers shall discard packets with unexpected destination address.

**Advantages:**

Was considered as the best way to deal with logical addresses that do not have any entry in the Logical Address Table

**Disadvantages:**

RMAP allows that a packet with LA 254 is sent to configuration port (0) of routers

# 5.2 Routers shall discard packets with unexpected destination address - Proposed changes to specification

- **Proposed change:** Remove the requirement on routers and replace it with a may to remind the user that it is an valid option.
- **Benefits:**
  - Make SpaceWire compliant with RMAP



# 6. Time-code master: one or more? – Change requests

| | | | | |
|---|---|---|---|---|
| **44** [Süss SpaceWire Nodes - June 2010] | 7.3 | 52 | **Change:**<br>[support multi Time-Code master] | Only one node in a SpaceWire network should provide the active TICK_IN signal which triggers the broadcast of the Time-Codes. This is to avoid collisions of Time-Codes within the network. For fail safety and redundancy reasons it can be useful to have simultaneous Time-Codes from different time masters in a system. This could be implemented by using the two remaining reserved states of the control flags. |
| **45** [Parkes ECSS-E-ST-50-12C changes.ppt slide 19] | 7.3 | 52 | **Change:**<br>Remove (c) note 2 and part of (d) | SpW-WG reserved time-codes<br>NASA use multiple time-codes<br>Both violate the existing standard |
| **69** [Isomaki RC1.1] | 8.12.2b | 84 | **Replace with the following:**<br>At any moment in time there shall be only a single node or router, the time-master, managing the distribution of time.<br>NOTE The node or router can use different link interfaces to transmit the time-codes. This allows for redundancy if a link is broken.<br>NOTE It is a allowed to switch the time mastery between different nodes or routers. | It is neither suitable nor feasible to restrict the time-code source to be a single link-interface. As there shall be only one time-counter in a node or router they shall be considered the source of the time-codes not a specific link interface. Redundancy is a desired feature in a SpaceWire network and thus it should be allowed for different link interfaces on different nodes or routers to handle the distribution of time as long as they are designed on system level not to do it at the same time. |

## 6. Time-code master: one or more? – Issues

The ECSS-E-ST-50-12C Standard does not forbid more than one clock master (for 64-bit Time-codes) to be active in a network (there is a “should”, not a “shall”)

**Advantages:**

Allows implementing clock master redundancy

**Disadvantages:**

Might lead to Time-Code collision or confusion in case of bad system design




## 6. Time-code master: one or more? - Proposed changes to specification

- **Proposed change:** **Keep the possibility open (and replace the “should” clause with some warning / advice in the Handbook)**
- **Benefits:**
  - **Allows implementing clock master redundancy**
- **Impact:**
  - ***It does not mean that the two control flags of the Time-code can be set to another value that 00 !!***

# 7. Introduction of backward compatible signalling codes

7.1 Backward compatibility with Time-codes

7.2 Interrups+ACK scheme

7.3 General signalling scheme, allowing time codes and interrupts and more





# 7.1 Time-code backward compatibility – Question to the WG

On one hand, the ECSS-E-ST-50-12C Standard foresees two control flags to be carried together with Time-codes (lowest latency) but on the other, these flags are reserved and shall be set to 00.

Some.

**Question:**

If the two control flags would be set to a different value in order to implement another type of low-latency signalling code (e.g. the scheme that was proposed and discussed within the SpW WG that uses control flags 01 to allow broadcasting 32 interrupt codes and 32 corresponding acknowledgement/clear codes with he same latency as Time-codes), would the SpW Working Group regard this as backward compatible ?

**ESA's position:**

YES

*Note that it is tricky because some devices might assume that the flags are 00 but not check it. These devices will accept any signalling code with different control flags as valid Time-codes.*

# 7.2 Interrups+ACK scheme – Change requests (1/4)

| | | | | |
|---|---|---|---|---|
| **86** [Sheynin Distributed Interrupts in SpaceWire Networks - Dec 2006] | 8.12.2 | 86 | **Insert:**<br>[attached file 8.13 Interrupts distribution (normative).pdf] | Introduction of Distributed Interrupts |
| **48** [Sheynin Distributed Interrupts in SpaceWire Networks - Dec 2006] | Figure 7-2 | 53 | **Replace figure with the one attached here.** | Introduction of Distributed Interrupts |
| **51** [Sheynin Distributed Interrupts in SpaceWire Networks - Dec 2006] | 7.3c | 53 | **Replace with:**<br>The other three control codes (Time-Code, Interrupt-Code and Interrupt_Acknowledge-Code) shall be formed from ESC followed by a single data character. | Introduction of Distributed Interrupts |





# 7.2 Interrups+ACK scheme – Change requests (2/4)

| | | | | |
|---|---|---|---|---|
| **52** [Sheynin Distributed Interrupts in SpaceWire Networks - Dec 2006] | 7.3c | 53 | **Insert:**<br>NOTE 3. The Interrupt-Code and Interrupt_Acknowledge-Code are used to distribute real-time interrupt signals from nodes that are sources of interrupts to nodes that can do interrupt processing procedures (see subclause 8.13). Interrupt/ Interrupt_Acknowledge-codes can eliminate system-wide sideband signals for low latency control signals distribution. | Introduction of Distributed Interrupts |
| **53** [Sheynin Distributed Interrupts in SpaceWire Networks - Dec 2006] | 7.3d | 53 | **Replace with:**<br>(C6=0, C7=0) | Introduction of Distributed Interrupts |

# 7.2 Interrups+ACK scheme – Change requests (3/4)

| | | | | |
|---|---|---|---|---|
| **54** [Sheynin Distributed Interrupts in SpaceWire Networks - Dec 2006] | 7.3e | 53 | **Insert:**<br>Five bits of interrupt information shall be held in the least significant five bits of the Interrupt-Code (I0-I4) and the three most significant bits (C5=0. C6=0, C7=1) shall contain control flags that are distributed isochronously with the Interrupt-<br>Code.<br>NOTE The Interrupt-Code is used to distribute interrupt request information and control flags (C5=0, C6=0, C7=1) isochronous with the Interrupt-Code distribution. | Introduction of Distributed Interrupts |




# 7.2 Interrups+ACK scheme – Change requests (4/4)

| | | | | |
|---|---|---|---|---|
| **55** [Sheynin Distributed Interrupts in SpaceWire Networks - Dec 2006] | 53 | | **Insert:**<br>Five bits of interrupt acknowledge information shall be held in the least significant<br>five bits of the Interrupt_Acknowledge-Code (I0-I4) and the three most significant<br>bits (C5=1, C6=0, C7=1) shall contain control flags that are distributed isochronously with the Interrupt_Acknowledge-Code.<br>NOTE The Interrupt_Acknowledge-Code is used to distribute interrupt acknowledge information and control flags (C5=1, C6=0, C7=1) isochronous with the Interrupt_Acknowledge-Code distribution. | Introduction of Distributed Interrupts |

## 7.2 Interrups+ACK scheme – Issues

Some scheme was proposed and discussed within the SpW WG that uses control flags 01 to allow broadcasting 32 interrupt codes and 32 corresponding acknowledgement/clear codes with he same latency as Time-codes.

**Advantages:**

- Allows broadcasting 32 interrupt codes with he same latency as Time-codes
- Keeps two options (of the four provided by the two control flags) reserved for future use

**Disadvantages:**

- Allows broadcasting only 32 interrupt codes
- Corresponding ACK codes must be implemented as well, not really for acknowledgment but for clearing the interrupts
- The concept of acknowledgement (high reliability, high latency) is not consistent with the one of interrupt (low reliability, low latency)
- The minimum duration between two similar interrupts is bounded by the ACK mechanism time



## 7.2 Interrups+ACK scheme - Proposed changes to specification – Option 1

- **Proposed change:** **Introduce as documented (Distributed Interrupts in SpaceWire Networks - Dec 2006, Sheynin)**
- **Benefits:**
  - **Allows broadcasting 32 interrupt codes with he same latency as Time-codes**
  - **Keeps two options (of the four provided by the two control flags) reserved for future use**
- **Impact:**
  - **Corresponding ACK codes must be implemented as well, not really for acknowledgment but for clearing the interrupts**
  - **The concept of acknowledgement (high reliability, high latency) is not consistent with the one of interrupt (low reliability, low latency)**
  - **The minimum duration between two similar interrupts is bounded by the ACK mechanism time**

## 7.2 Interrups+ACK scheme - Proposed changes to specification – Option 2

- **Proposed change:** **Extend the concept to multi-purpose low-latency signalling codes that could be used for the distribution of times, of interrupts, and more TBD.**
- **Benefits:**
  - **See next slides**
- **Impact:**
  - **See next slides**




## 7.3 Multi-purpose signalling scheme – Change requests (1/3)

| | | | | |
|---|---|---|---|---|
| **46** [Ferrer - spw new version albert comments.ppt slide 8] | 7.3 | 52 | **Redefine Time-Codes:**<br>Proposal to define Time-Codes as a type of ESC+Data character sequence. This special sequence can be called "escape data characters" or "signalling codes" or "escape codes". | Current definition states:<br>"The Time-Code is used to distribute system time information and control flags isochronous with the time-code distribution."<br>If Time-Codes are going to be used for other purposes the definition must be changed.<br>Escape codes are very important because they can bypass the flow control mechanism.<br>- In case of packet blocking they can still be sent<br>They have minimum latency and jitter.<br>They can contain minimum information<br>They are limited<br>- If possible, some values should be reserved for future SpW development<br>If possible, same control code should imply same behaviour.<br>Mandatory functions of theses codes should be very simple to implement in hardware. |

# 7.3 Multi-purpose signalling scheme – Change requests (2/3)

| | | | | |
|---|---|---|---|---|
| **47** [Ferrer - spw new version albert comments.ppt slides 11, 19 and 20] | 7.3 | 52 | Restrict 64-bit Time-code scheme to <T6,T7>=<0,0> and use the other three combinations to implement Signalling codes, a number of them maybe dedicated to time distribution, others to interrupt distribution, etc. | [...]<br>Given these three points, and keeping the ESC+data character scheme, we could define not "Time-codes" but "Signalling codes". As explained above, each Signalling code requires 2 bits. This leaves 6 bits that allow defining 64 Signalling codes. A number of them can be used as time codes (allowing by the way the distribution of more than one time scheme; e.g. a 50us time scheme as well as a 1ms time scheme and a 125ms time scheme). A number of them can be dedicated to interrupt distribution (with no acknowledgement since this kind of signalling usually does not require any; or Signalling code <N,s,f> (where N is the 6-bit Signalling code label while s is the state bit and f is the flipping bit) can be the interrupt and Signalling code <N+1, s,f> can be the interrupt acknowledgement if the latter is really required). The only problem of this Signalling code scheme is that it is not backward compatibility with SpaceWire 1.0. But, if we consider that, in practice, all existing implementations of SpaceWire Time-codes are using <00> as the two most significant bits ("control flags" T6 and T7), we can keep this and implement the Signalling code concept with <01>, <10> and <11> as only possible values for T6 and T7. This leaves 2^4*3=48 possible Signalling codes. |



# 7.3 Multi-purpose signalling scheme – Change requests (3/3)

| | | | | |
|---|---|---|---|---|
| **49** [Ferrer - spw new version albert comments.ppt slide 11] | Figure 7-2 | 53 | **Requirements on the introduction of side-band interrupt signalling based on control codes:**<br>Proposed interrupt codes use Escape+data characters to broadcast a value to the network.<br>Two problems must be solved<br>1. Avoid a spurious value to be broadcasted<br>2. Avoid infinite transmission due to loops<br>Timeout requires configuration and a counter in the routers for each possible value .<br>Proposal: A different control codes (or any other bit change) must be received each time to enable the value to be broadcasted. (requires 64 bits per port)<br>Interrupts distribution could be designed so that its implementation supports other uses.<br>(rename to signalling codes) | |

## 7.3 Multi-purpose signalling scheme – Issues (1/2)

**Point 1**

- The current Time-Code scheme does not provide the possibility to 'instantly' distribute any form of absolute time across the SpaceWire network (because the "time information value" is limited to 64 values). It provides 'instant signalling' (with some latency that can be negligible for low time-accuracy applications and bounded for high time-accuracy applications) of:
    - a state (provided by one of the 64 possible "time information" values, usually value 0)
    - an incremental tick (the fact that the value is incremented)
- Any implementation that is trying to use the value of the Time-code to provide time information will be always limited and therefore very application specific
    - e.g. the epoch of a scheduled communication cycle will have to be 64 although the control loop might require any number of communications within a loop
    - e.g. the epoch will have to be very short (in the order of tens of microseconds) in order to allow frequent time synchronisation points, although control loops vary from 1microsecond for advanced robotics to 100ms or 125ms for spacecraft control
    - e.g. physical values such as 100ms are not easily divided by 64



## 7.3 Multi-purpose signalling scheme – Issues (2/2)

**Point 2**

- From the point of view of the information theory, the same information can be coded on 2 bits: state and tick (e.g. the reset state is <0x> where x is either 0 or 1 depending on its previous value; and any following tick is <1x> where x is either 0 or 1 depending on its previous value; in other word, a time-code is in fact <b1, b2> where b1 is 0 in case of state reset and 1 in tick increment mode; and b2 is always flipping to indicate a new time-code)

**Point 3**

- . The 'instant signalling' of state+tick can be used to distribute time-codes but also interrupts or any kind of low-latency signal

## 7.3 Multi-purpose signalling scheme – Proposed changes to specification (1/3)

- **Proposed change:** Define Time-Codes as a sub-type of ESC+Data character sequence. This special sequence can be called “signalling codes”.
- **Benefits**:
  - Multi-purpose low-latency Signalling Codes can also be made backward compatible with Time-codes (like the Interrup+ACK scheme).
  - They allow for the distribution of any other low latency signal.
  - Each Signalling Code requires 2 bits. This leaves 6 bits that allow defining 64 Signalling codes.
  - A number of them can be used as time codes
    - allowing the distribution of more than one time scheme
    - e.g. a 50µs time scheme as well as a 1ms time scheme and a 125ms time scheme.



## 7.3 Multi-purpose signalling scheme – Proposed changes to specification (2/3)

- **Benefits (cont’d)**:
  - A number of them can be dedicated to interrupt distribution
    - with no acknowledgement since this kind of signalling usually does not require any
    - or Signalling Code <N,s,f> (where N is the 6-bit Signalling code label while s is the state bit and f is the flipping bit) can be the interrupt and Signalling Code <N+1, s,f> can be the interrupt acknowledgement if the latter is really required.

# 7.3 Multi-purpose signalling scheme – Proposed changes to specification (3/3)

- **Impact:**
  - **The only problem of this Signalling code scheme is that it is not backward compatibility with ECSS-E-ST-50-12C Time-codes. But, if we consider that, in practice, all existing implementations of SpaceWire Time-codes are using <00> as the two most significant bits ("control flags" T6 and T7), we can keep this and implement the Signalling Code concept with <01>, <10> and <11> as only possible values for T6 and T7. This leaves 2^4*3=48 possible Signalling Codes.**
  - **The semantics of the multi-purpose low-latency signalling codes used in a system must be defined for this system. Widely used signals are likely to be standardised in the future.**



# 8. Introduction of simplex and/or half-duplex – Change requests (1/2)

| | | | | |
|---|---|---|---|---|
| **61** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 8 | 57 | **Add simplex and/or half-duplex mode.** | For many high speed payload data applications only a simplex connection from the instrument to the memory is required. In these cases the back channel provided by SpaceWire is often seen as unnecessary complexity and cable mass. It has been proposed to modify the SpaceWire codec and the state machine to support simplex operation [11], [12]. Also the possibility of a half-duplex SpaceWire implementation has been suggested [13].<br>It remains to be investigated what consequences these changes will have for the backwards compatibility of SpaceWire and if they should be included in the update of the standard. |
| **62** [Seynin - SpaceWire Standard Evolution .Sheynin .ppt slide 11] | 8 | 57 | **Add**<br>simplex SpaceWire | Using two new signals – tx_simplex_enabled and rx_simplex_enabled<br>two types of the simplex mode link operation – transmitting simplex or receiving simplex.<br>Transmitting:transmitter sends data for N*12,8 microseconds.<br>Reconnecting:transmitter goes to Connecting State and sends only NULL symbols on the frequency 10MHz for 12,8*K microseconds. |

## 8. Introduction of simplex and/or half-duplex – Issues

The ECSS-E-ST-50-12C Standard specifies only full-duplex communication in links.

**Advantage:**

Simple and symmetric scheme

Simple flow control mechanism using the return "link"

**Disadvantages:**

For many high speed payload data applications only a simplex connection from the instrument to the memory is required. In these cases the back channel provided by SpaceWire is often seen as unnecessary complexity and cable mass.





## 8. Introduction of simplex and/or half-duplex – Proposed changes to specification

It is the wish of ESA to include these features in the updated SpaceWire standard provided that breadboarding validates backward compatibility and that introduction of these features does not delay the issue of the updated standard.

- **Proposed changes:**
  - **It has been proposed to modify the SpaceWire codec and the state machine to support simplex operation. Also the possibility of a half-duplex SpaceWire implementation has been suggested.**
  - **It remains to be investigated what consequences these changes will have for the backwards compatibility of SpaceWire and if they should be included in the update of the standard.**
- **Benefits:**
  - **Mass and complexity reduction for end-of-the-line devices (simplex)**
  - **Mass and complexity reduction for end-of-the-line devices while keeping commandability (half-duplex)**

Otherwise, half-duplex and/or simplex could be standardised as part of a different "SpaceWire inspired" ECSS standard.

# 9. Miscellaneous change requests







# 9.1 Misleading references to Virtual Channels – Change requests

| | | | | |
|---|---|---|---|---|
| **87** [Parkes ECSS-E-ST-50-12C changes.ppt slide 22] | Figure 10-3 | 93 | **Remove "virtual channel"** | Remove all text related to virtual channels |
| **88** [Parkes ECSS-E-ST-50-12C changes.ppt slide 22] | 10.1.2.8 | 93 | **Remove section** | Remove all text related to virtual channels |
| **97** [Parkes ECSS-E-ST-50-12C changes.ppt slide 22] | 10.5.4.3 NOTE1 | 103 | **Remove section** | Remove all text related to virtual channels |

# 9.1 Misleading references to Virtual Channels – Issues

The ECSS-E-ST-50-12C Standard makes several informative references to the possibility to implement Virtual Channels with SpaceWire.

**Advantage:**

**Disadvantage:**

This has created a lot of confusion and misunderstandings.




# 9.1 Misleading references to Virtual Channels – Proposed changes to specification

- **Proposed changes:** **remove all references to Virtual Channels**
- **Benefits:**
  - **Remove confusion**

# 9.2 High time-synchronisation resolution option – Change requests

| | | | | |
|---|---|---|---|---|
| **60** [Pinsard - CR1.1] | 7.7h | 56 | **Insert:**<br>i. high time-synchronisation resolution option:<br>On the transmitter part:<br>· When a high resolution synchronisation is needed a jitter-correction Time-Code could be sent just after the usual Time-Code that carries the six-bit time.<br>· This jitter-correction Time-Code is built as follow:<br>- the two control flags are set to One in order to avoid any confusion with any other use of the Time-Code<br>- The Four lowest bits are equal to the number M of bits sent between the Tick-In signal assertion and the output on Dout of the first data-control flag bit of the Time-Code (ESC data-control flag bit)<br>- The two left bits are reserved for future use and shall both be set to zero.<br>On the receiver part:<br>· A synchronisation signal shall be asserted after a number (64 minus M) of receiver bits from the arrival of the first data-control flag bit of the Time-Code (ESC data-control flag bit).<br>See example in attached file "high time-synchronisation resolution option - example.pdf" | To improve the time synchronisation the following requirement could be added to the SpaceWire standard in section 7.7 time interface<br>The implementation of this requirement is low resource consuming and will allow SpaceWire to be use were high accuracy synchronisation is needed (better than 10µs). |




# 9.2 High time-synchronisation resolution option – Issues

It has been proposed to implement some high resolution time broadcasting based on the use of two types of Time-codes (regular Time-codes + “delta” Time-codes).

**Advantage:**

Increase the resolution of time broadcasting

**Disadvantage:**

Makes use of the two reserved control flags.

## 9.2 High time-synchronisation resolution option – Proposed changes to specification

- **Proposed changes:**
  - Do not adopt
  - Keep it as input to SpaceWire 2.0
- **Benefits:**
  - Backward compatibility



## 9.3 Introduce broadcast / multicast – Change requests

| | | | | |
|---|---|---|---|---|
| **93** [Seynin - SpaceWire Standard Evolution.Sheynin.ppt slide 12] | 10.2.7 | 99 | **Insert** Broadcast/multicast modes in SpaceWire interconnections | In the standard it is limited to router-to-node.It can be extended for router-to-router for some interconnection topologies, (e.g. tree) and accurate routing tables writing |

## 9.3 Introduce broadcast / multicast – Issues

It has been proposed to introduce multicast and/or broadcast capability (with no related technical proposal).

**Advantage:**

Many applications

**Disadvantage:**

Probably implies non backward compatible modifications of the Character Level.





## 9.3 Introduce broadcast / multicast – Proposed changes to specification

- **Proposed changes:**
  - **Do not adopt**
  - **Keep it as input to SpaceWire 2.0**
- **Benefits:**
  - **Backward compatibility**

# 9.4 Requirement on Regional Addressing – Change requests

| | | | | |
|---|---|---|---|---|
| **92** [Isomaki RC5.1] | 10.2.3i | 97 | **Define larger or remove requirement completely.** | This is not a requirement as larger is not defined which breaks the ECSS standardization rules. |





# 9.4 Requirement on Regional Addressing – Issues

The ECSS-E-ST-50-12C Standard specifies that "Regional addressing shall be used for larger networks with each cluster limited to a maximum of 224 logical addresses.".

**Advantage:**

Hint

**Disadvantage:**

"Larger" cannot be a requirement.

# 9.4 Requirement on Regional Addressing – Proposed changes to specification

- **Proposed changes:**
  - **Remove clause**

- **Benefits:**
  - **Improves readability**



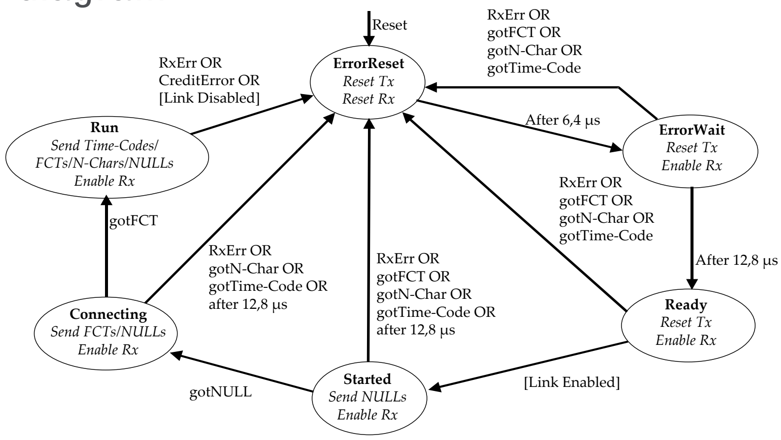


# 9.5 Update state machine – Change requests

| | | | | |
|---|---|---|---|---|
| **65** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 8.5 | 63 | **Change state diagram.** | During the implementation of the SpaceWire codec some inconsistencies in the transitions described in the state diagram have been identified [10].<br>a) The transition from Started to ErrorReset is impossible when gotNULL condition is set.<br>b) The transition from Connecting to Run shall be applied only after sending FCT to channel.<br>These inconsistencies will have to be corrected by making some slight modifications of the standard text and state diagrams. |
| **66** [Seynin - SpaceWire Standard Evolution.Sheynin.ppt slide 10] | 8.5 | 63 | **Add requirement** "always to send FCT before going to the RUN state" | An only sending node can never set a connection |
| **67** [Isomaki RC4.3] | 8.5.2.7a NOTE | | **Make the NOTE a requirement instead:**<br>8.5.2.7c The receiver is enabled.<br>8.5.2.7d The transmitter is enabled to send Time-codes, FCTs, N-Chars and NULLs. | It is not specified in a requirement anywhere in the standard that the transmitter should be enabled to transmit all four character in the run-state. This is only written in descriptive text (and in the state diagram figure which is only referenced from descriptive text). |

# 9.5 Update state machine – Issues

A shortcoming has been identified in the ECSS-E-ST-50-12C Standard state diagram.




RxErr = Disconnect error OR Parity error OR Escape error (ESC followed by EOP or EEP or ESC).

NDisconnect error only enabled after First Bit Received. Parity Error, Escape Error, gotFCT, gotN-Char, gotTime-Code only enabled after First NULL Received (i.e. gotNULL asserted). Thus RxErr OR gotFCT OR gotN-Char OR gotTime-Code is really RxErr OR (gotNULL AND (gotFCT OR gotN-Char OR gotTime-Code)).





# 9.5 Update state machine – Proposed changes to specification

- **Proposed changes:**
  - **Add requirement "always to send FCT before going to the RUN state"**
- **Benefits:**
  - **Improves SpaceWire state diagram**

# 9.6 After reset the time-counter shall be set to zero – Change requests (1/2)

| | | | | |
|---|---|---|---|---|
| **80** [Isomaki RC3.4] | 8.12.2m | 85 | **Replace with the following:**<br>After reset the time-counter shall be set to zero. | It is not feasible to reset the time-counter when each individual link enters error-reset. Then the whole time distribution will be disturbed just because one link had a disturbance. It should instead only be specified that the time-counter shall be zero after reset/startup. The control flags do not need to be specified here since only the count is relevant to the time-distribution. |
| **81** [Parkes ECSS-E-ST-50-12C changes.ppt slide 20] | 8.12.2m | 85 | **Replace with the following:**<br>After reset the time-counter shall be set to zero. | This is incorrect and stops time-codes working briefly after a link disconnect. |
| **82** [Hihara RC1.1] | 8.12.2.m | | After reset or disconnect-reconnect (state machine in ErrroReset state) the time-counters <u>in time master nodes and end nodes, excluding routers</u>, shall be set to zero and any control-flag outputs shall be set to zero. | Since SpaceWire routers are connected to multiple nodes, its internal time-counter does not have to be initialized after reset or disconnect-reconnect occurs in one port.<br>- The statement "After reset or disconnect-reconnect (state machine in ErrorReset state) the time-counter shall be set to zero and any control-flag outputs shall be set to zero." would not be suitable for router use.<br>- Since a router accommodates several SpaceWire links, the internal counter, which is described as "the router's time- counter" in term k and l, should not be reset. In other words, one reset operation on a link should not have influence on other links. |



# 9.6 After reset the time-counter shall be set to zero – Change requests (2/2)

| | | | | |
|---|---|---|---|---|
| **83** [Nomachi - SpaceWire-modification_request.v1 - Masaharu Nomachi.ppt slide 2] | 8.12.2m | 85 | **Change:**<br>[This specification would be applied for time master node only.This specification would be applied for end nodes (reserved counters in receivers), excluding non-time master routers.] | The statement "After reset or disconnect-reconnect (state machine in ErrorReset state) the time-counter shall be set to zero and any control-flag outputs shall be set to zero." would not be suitable for router use.<br>Since a router accommodates several SpaceWire link, the internal counter, which is described as "the router's time- counter" in term k and l, should not be reset. In other words, one reset operation on a link should not have influence on other links. |

## 9.6 After reset the time-counter shall be set to zero – Issues

The ECSS-E-ST-50-12C Standard specifies that “After reset the time-counter shall be set to zero”.

**Advantage:**

**Disadvantage:**

It is not feasible to reset the time-counter when each individual link enters error-reset. Then the whole time distribution will be disturbed just because one link had a disturbance.



## 9.6 After reset the time-counter shall be set to zero – Proposed changes to specification

- **Proposed changes:**
  - **Remove clause**
- **Benefits:**
  - **Improves Time-code management**

# 9.7 Switching arbitration algorithm – Change requests

| | | | |
|---|---|---|---|
| **89** [Ferrer - spw new version albert comments.ppt slide 11] | 10.1.2.9.6 | 96 | **Inconsistency:**<br>last paragraph of section 10.1.2.9.6:<br>"In the event of several packets competing for a set of links, subclause 10.2.5 specifies the means of arbitration when an output port becomes available, giving access to the newly freed output port to the packet with the highest priority destination address"<br>Section 10.2.5<br>"SpaceWire routing switches shall provide a means of arbitrating between input ports requesting the same output port."<br>-> Does not oblige the use of a specific arbitration algorithm |





# 9.7 Switching arbitration algorithm – Issue (inconsistency)

last paragraph of section 10.1.2.9.6:
"In the event of several packets competing for a set of links, subclause 10.2.5 specifies the means of arbitration when an output port becomes available, giving access to the newly freed output port to the packet with the highest priority destination address"

Section 10.2.5
"SpaceWire routing switches shall provide a means of arbitrating between input ports requesting the same output port."
-> Does not oblige the use of a specific arbitration algorithm

## 9.7 Switching arbitration algorithm– Proposed changes to specification

- **Proposed changes:**
  - Make clear that arbitration policy (at router ports) is not specified
- **Benefits:**
  - Improves readability





## 9.8 Router timeout – Change requests

| | | | |
|---|---|---|---|
| **90** [Süss - SpaceWire Standard Evolution - Nov. 2008] | 10.2 | 96 | **Add router timeout.** |
| **91** [Parkes ECSS-E-ST-50-12C changes.ppt slide 23] | 10.2 | 96 | **Add:**<br>[Add router time-out requirements] |

## 9.8 Router timeout – Issues

The ECSS-E-ST-50-12C Standard does not specifies that routers shall spill “still” packets after some timeout but this feature is included in the SpW-10X.

**Advantage:**

Avoids specifying a feature which is outside of the protocol stack (spilling “blocked” packets could be done in other ways, at application level)

Timeouts are highly non-linear and their use is limited because non-deterministic

**Disadvantage:**

Prevents autonomous spilling of “blocked” packets by the router.



## 9.8 Router timeout – Proposed changes to specification

- **Proposed changes:**
  - **Open point**
- **Benefits:**

# 9.9 State of the link interface during the spilling of a packet – Change requests

| | | | | |
|---|---|---|---|---|
| **96** [Larsen RC1.1] | 10.5.2 | 101 | **Request** that the state in which the SpaceWire link interface should be in during the spilling of a packet be defined. | Assume a large packet is being spilled on a SpW port. What state should the link halt in? Section 10.5.2 states that if an error is detected by either the source or destination node that the packet will be "spilled" if the pack being spilled is quite large it could take some time to rid the link of the error packet. f. Then goes on to state "the link shall not restart after an error until some N-Chars are read..." it does not state the state the SpW link should be in while/after the packet is spilled. Should the link be in the ErrorWait state? Ready state and not send data until some N-Chars are received? (per section 8.5 figure 8-2). |





# 9.9 State of the link interface during the spilling of a packet – Issues

Assume a large packet is being spilled on a SpW port. What state should the link halt in? Section 10.5.2 states that if an error is detected by either the source or destination node that the packet will be "spilled" if the pack being spilled is quite large it could take some time to rid the link of the error packet. f. Then goes on to state "the link shall not restart after an error until some N-Chars are read..." it does not state the state the SpW link should be in while/after the packet is spilled. Should the link be in the ErrorWait state? Ready state and not send data until some N-Chars are received? (per section 8.5 figure 8-2).

**Advantage:**

Change Request not understood

**Disadvantage:**

# 9.9 State of the link interface during the spilling of a packet – Proposed changes to specification

- **Proposed changes:**
  - Open point (Change Request not understood)

- **Benefits:**



# 9.10 Over specification of host interface – Change requests

| | | | | |
|---|---|---|---|---|
| **58** [Isomaki RC6.2] | 7.6 | 55 | **The clause should specify everything** without an explicit data width or require that everyone uses 8-bits+control bit. EEP and EOP could be specified with saying that the control bit is 1 and the lsb data bit is 0 (EOP) or 1 (EEP). | It seems unnecessary to have a lot of requirements for a specific implementation. It is better to write the requirement in general terms. Otherwise it should be specified that everyone MUST use 8-bit width. |
| **70** [Isomaki RC1.2] | 8.12.2c | 84 | **Remove** | How a time-code is transmitted is clear from clause 7. This section should only specify how time is distributed that is how the time-counter is changed and how the value is propagated on a network. |
| **71** [Isomaki RC1.3] | 8.12.2d | 84 | **Replace with the following:**<br>To distribute time the time-master shall do the following:<br>1. The time-counter is incremented by one.<br>2. The control flags are set to zero.<br>3. A time-code is constructed from the new time-counter value and the control flags.<br>The resulting time-code is transmitted on all link interfaces in the time-master. | Original description was not clear about where a time counter was located but indicated that one should be located in each link interface. This seems not to be what was actually intended from the beginning since other descriptive parts (8.4.2) of the standard indicate that when tick in is asserted then the time-code presented on a time-code input should be transmitted. This also seems to be in line with existing codec implementations such as the UoD codec. In my view the most reasonable thing to do is to entirely skip the talk of TICK_IN and similar signals in this section and only talk about what the clause title says that is: time distribution. It is specified how the time-counter is updated and to where the new time-count shall be sent. It should not specify how the time-code is transmitted. Clause 7 specifies a signal interface for time-codes. If one is present then a time-code should be transmitted as indicated there. Other implementations perhaps have the time distributer integrated in the link interface and does not need an external interface. Thus it is unnecessary to refer to specific signals here. |

## 9.10 Over specification of host interface – Issues (1/2)

The ECSS-E-ST-50-12C Standard specifies the host interface for data characters as well as EEP and EOP.

**Advantage:**

Intention was to facilitate interoperability at IP level

**Disadvantage:**

It seems unnecessary to have a lot of requirements for a specific implementation. It is better to write the requirement in general terms. Otherwise it should be specified that everyone MUST use 8-bit width.





## 9.10 Over specification of host interface – Issues (2/2)

Section 8.12.2 is not clear about where a time counter is located but indicates that one should be located in each link interface. This seems not to be what was actually intended from the beginning since other descriptive parts (8.4.2) of the standard indicate that when TICK_IN is asserted then the time-code presented on a time-code input should be transmitted. This also seems to be in line with existing codec implementations such as the UoD codec. The most reasonable thing to do is to entirely skip the talk of TICK_IN and similar signals in this section and only talk about what the clause title says that is: time distribution. It is specified how the time-counter is updated and to where the new time-count shall be sent. It should not specify how the time-code is transmitted. Clause 7 specifies a signal interface for time-codes. If one is present then a time-code should be transmitted as indicated there. Other implementations perhaps have the time distributer integrated in the link interface and does not need an external interface. Thus it is unnecessary to refer to specific signals here.

# 9.10 Over specification of host interface – Proposed changes to specification

- **Proposed changes:**
  - Streamline host interface (7.6)
    - Parameters and their format should be specified, not their implementation/encoding
  - Streamline Time distribution mechanism and time interface

- **Benefits:**
  - Avoids specifying features which are outside of the protocol stack
  - These "internal" interfaces for most users are in fact external interfaces for IP core vendors; over-specification therefore matters




# 9.11 Credit count error protection – Change requests

| | | | | |
|---|---|---|---|---|
| **63** [Hihara RC1.2] | 8.3e 2 | 58 | **Insert:** 3. Credit count in the transmitter and the receiver might be checked, or the flow control could be re-established within upper protocol layers. | Due to some reasons, FCT transmission sometimes vanishes("dead lock" in other words). One major cause of FCT disappearance is considered as the discrepancies of credit counters between an initiator and a target. - Transmission error is considered in current specification, whereas some specific case, in that the credit counter in sending end becomes less than the one in receiving end due to some reason, has to be considered. - Strictly speaking, a credit counter in a receiving end, which corresponds to 8.3.c is not specified explicitly. |
| **64** [Nomachi - SpaceWire-modification_request.v1 - Masaharu Nomachi.ppt slide 4] | 8.3e 2 | 58 | **Change:** [Is additional state transition required for continuous SpaceWire communication ?] | Many people experience the state in which FCT transmission vanishes when some error occurs. |

## 9.11 Credit count error protection – Issues

The ECSS-E-ST-50-12C Standard ensures link flow control through the exchange of FCTs.

**Advantage:**

Provides simple low-level low-overhead flow control at link level

**Disadvantage:**

Some people experience the state in which FCT transmission vanishes when some error occurs.





## 9.11 Credit count error protection – Proposed changes to specification

- **Proposed changes:**
  - **None**

- **Benefits:**
  - **Backward compatibility at Exchange Level**

# 10. Inputs to the SpW Handbook – Change requests (1/2)

| | | | | |
|---|---|---|---|---|
| **7** DS - 23 sept. 10 13:17 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 4.2.2 | 24 | | Differential characteristic impedance matched<br>Remark: LVDS is not impedance matched in Common Mode (CM). That means the LVDS is vulnerable to CM voltage exceeding a certain threshold at receiver inputs. ex: ±0.8 Volt from DC to about 10kHz. Above 10kHz the shield becomes effective but the ability of the receiver to reject CM voltage disturbance decreases when increasing the frequency. A good immunity to external CM disturbances is usually expected above 10kHz, thanks to the shield, but not documented.<br>That's the meaning of "good" in the last point ! rather an expectation instead of a valid/measurable requirement. |
| **10** DS - 23 sept. 10 13:45 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 4.3.2 | 27 | | See DS's previous note.<br>This declaration has a very limited practical extent. Probably a very good immunity for space application but not documented. It is suspected the LVDS being particularly susceptible to conducted ESD tests (bit flip) due to signal clipping at the receiver ports. Comparatively RS422 and RS232 offer a much higher immunity to offending CM voltage. |



# 10. Inputs to the SpW Handbook – Change requests (2/2)

| | | | | |
|---|---|---|---|---|
| **33** DS - 23 sept. 10 15:21 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 5.5.2.1a | 43 | | For transmitted bit rates much lower than 200Mb/sec, the LVDS frequency bandwidth can be limited using a pair of capacitive load at the transmitter output terminals. This method is particularly useful to reduce EMI on low-level signals within a unit. |
| **34** [Parkes ECSS-E-ST-50-12C changes.ppt slide 15] | 6.2 | 44 | **Change:**<br>Add clarification that the 100 k ohm input impedance is for the receiver chip only<br>If does not include bias resistors used for prevention of noise induced switching when input is open circuit. | Recommended practice with LVDS |
| **35** DS - 23 sept. 10 17:59 in ECSS-E-ST-50-12C for SpW Evolutions internal review_JI_DSannoted.pdf | 6.2 | 44 | High PCB ground plane to unit chassis inductance | |

## 10.1 LVDS EMC susceptibility

–LVDS is not impedance matched in Common Mode (CM). That means the LVDS is vulnerable to CM voltage exceeding a certain threshold at receiver inputs. E.g.: ±0.8 Volt from DC to about 10kHz. Above 10kHz the shield becomes effective but the ability of the receiver to reject CM voltage disturbance decreases when increasing the frequency. A good immunity to external CM disturbances is usually expected above 10kHz, thanks to the shield, but not documented.

–It is suspected the LVDS being particularly susceptible to conducted ESD tests (bit flip) due to signal clipping at the receiver ports. Comparatively RS422 and RS232 offer a much higher immunity to offending CM voltage.



## 10.2 Recommended practice with LVDS

–For transmitted bit rates much lower than 200Mb/sec, the LVDS frequency bandwidth can be limited using a pair of capacitive load at the transmitter output terminals. This method is particularly useful to reduce EMI on low-level signals within a unit.

–Add clarification that the 100KOhm input impedance is for the receiver chip only. It does not include bias resistors used for prevention of noise induced switching when input is open circuit.

# Conclusion

1. Achievements
    a. The SpW WG approved today as many dispositions as possible
    b. Thank you
2. Next steps
    a. Finalise the scope and technical solutions for the updated SpaceWire
    b. Start ECSS standardisation process