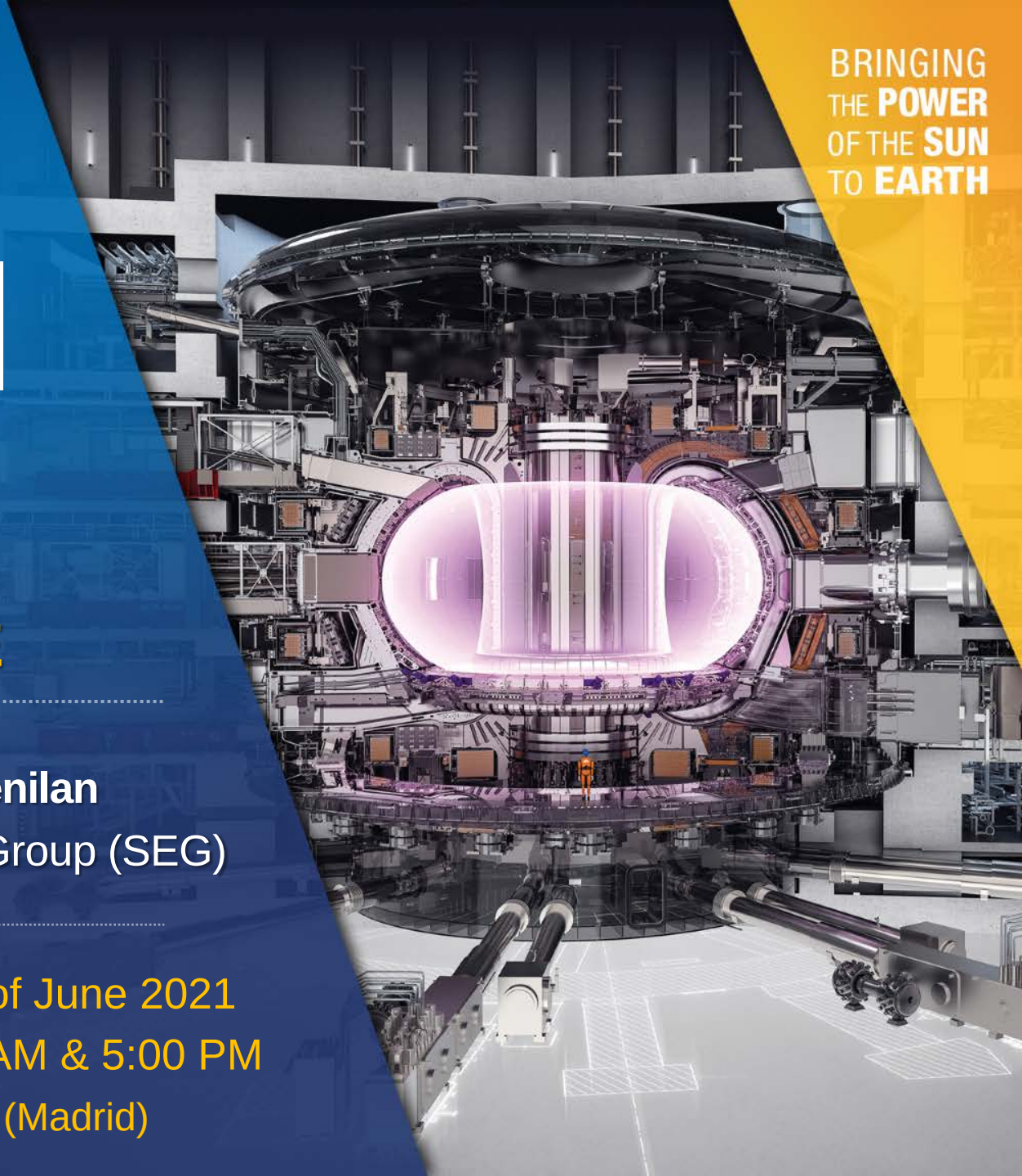
FUSION FOR ENERGY

THE REUSE COMPANY



BRINGING THE POWER OF THE SUN TO EARTH

Tailoring and Deployment of SE Suite in F4E

Aldo Schaaf & Ivan Bénilan

Systems Engineering Group (SEG)

TRC Webinar: 29th of June 2021

9:00 AM & 5:00 PM CEST (Madrid)

UID: 2SCWWV

Version: v1.2

FUSION FOR ENERGY

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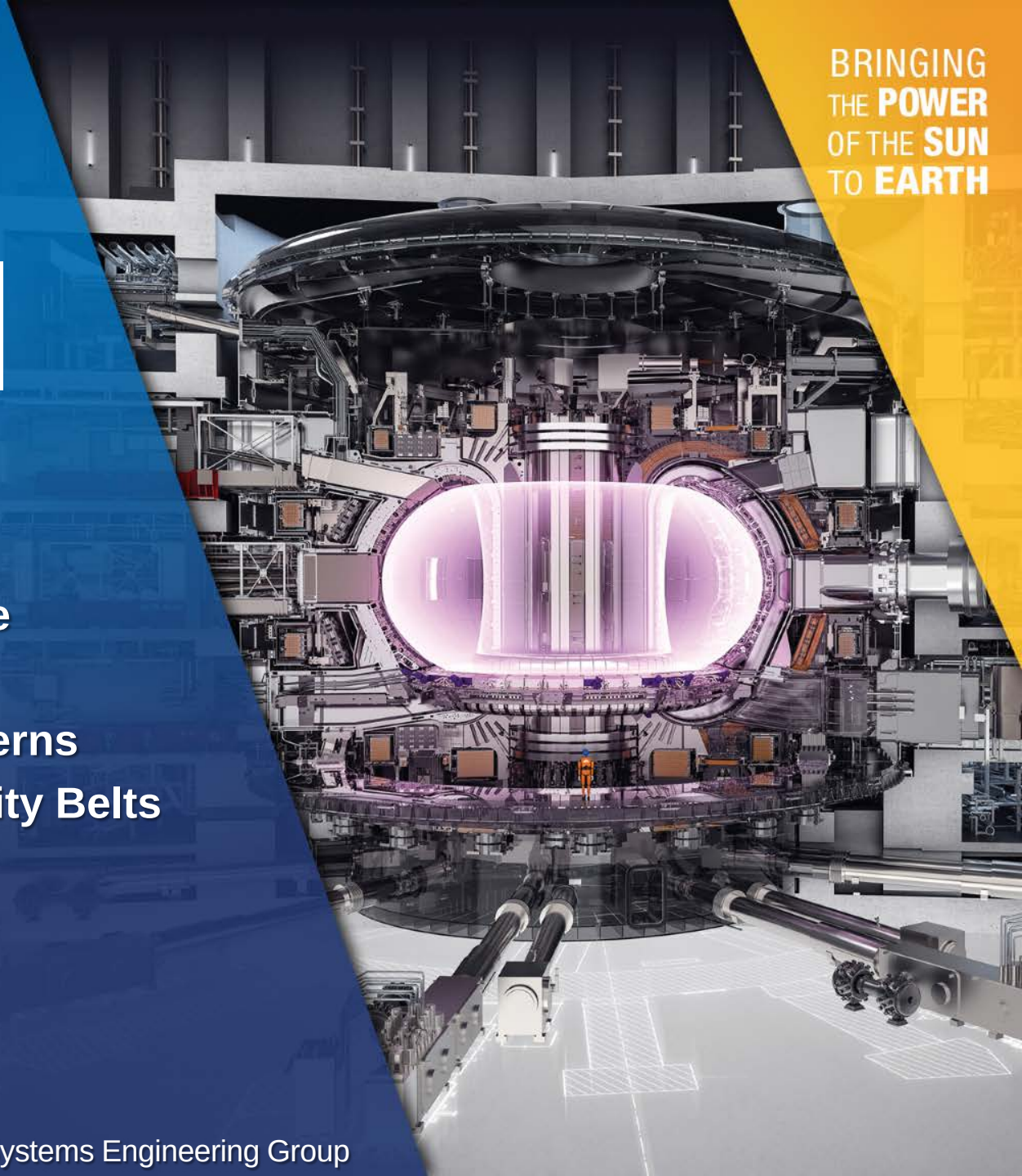


Content

1. Introduction
2. Traineeship Scope
3. SE Literature
4. Requirement Patterns
5. Tailoring the Quality Belts
6. Methodolgy
7. Results
8. Conclusion

Aldo Schaaf & Ivan Bénilan - Systems Engineering Group

1. Introduction – Telephone Game

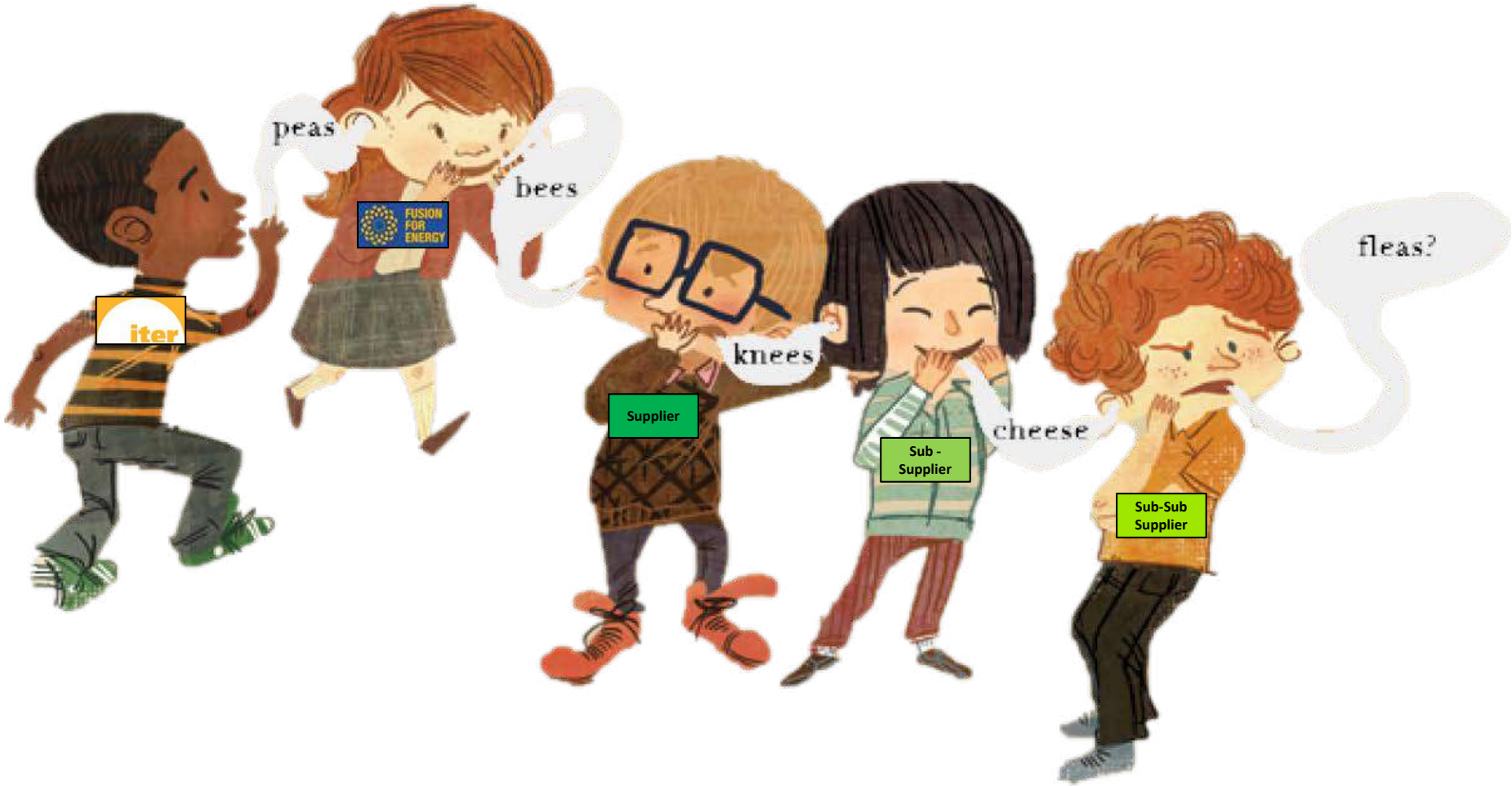
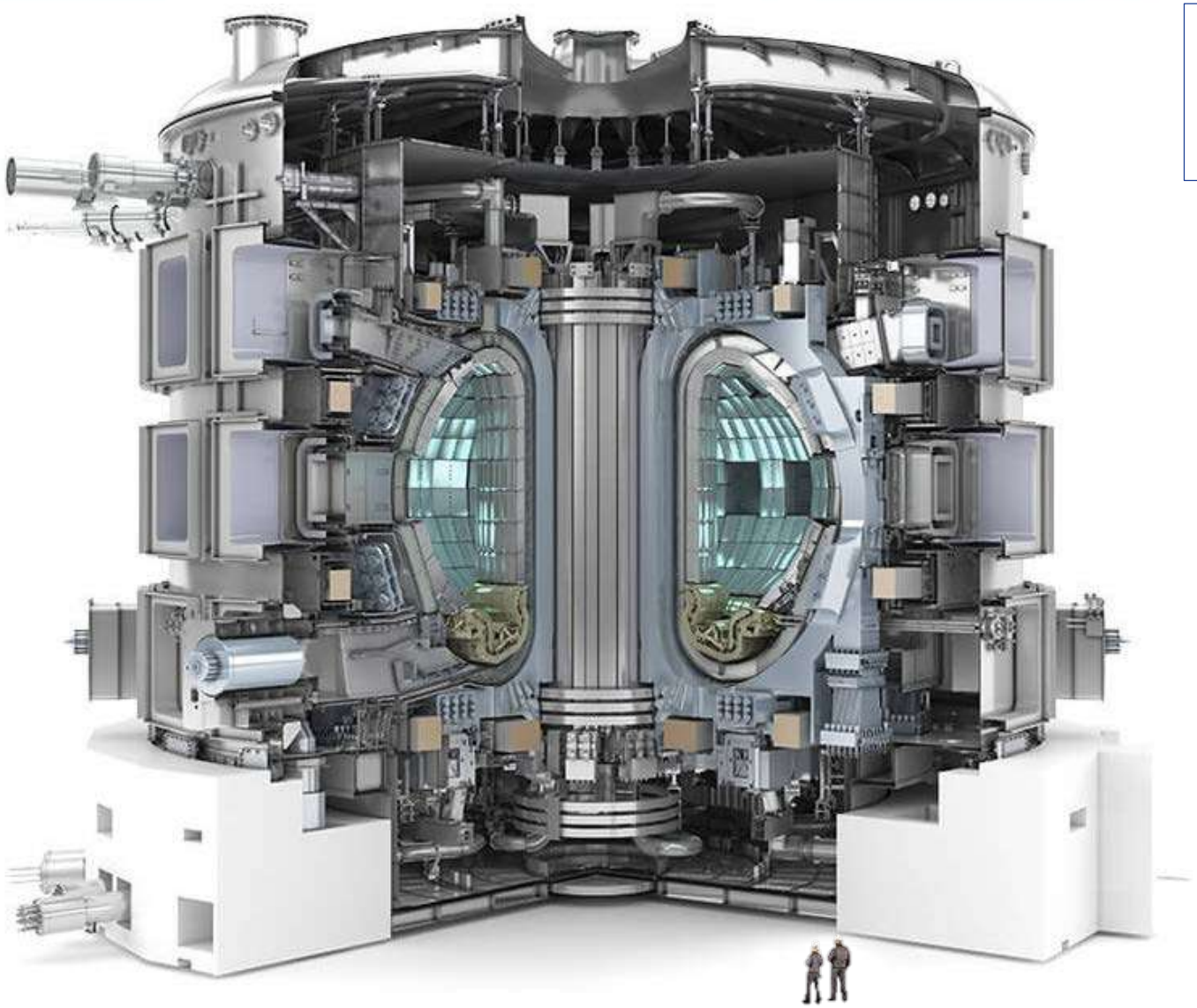


Image Source (URL): Telephone Game

1. Introduction – The ITER Project



F4E is the European Union organization managing Europe's contribution to ITER

Fusion Energy Output

500 MW, Q = 10

Plasma Temperature

150 million °C

Tokamak Dimensions

24 m high

30 m wide

Tokamak Weight

23 000 tonnes

Tokamak Components

1 000 000

1. Introduction – The RMV Process

Requirements Management and Verification (RMV) Process

700+ Technical Specifications ⟺ **80 000+** Technical Requirements

Analyze requirements

- Identify Applicable Documents (Level N)
- Identify Requirements (Level N)
- Analyze Requirements (Level N)

Propagate requirements

- Author Requirements (Level N+1)
- Trace Requirements Level N+1 to Level N
- Justify Requirements

Verify requirements

- Maintain Compliance
- Verify Requirements (Level N+1)
- Verify Requirements (Level N)

1. Introduction – The RMV Process

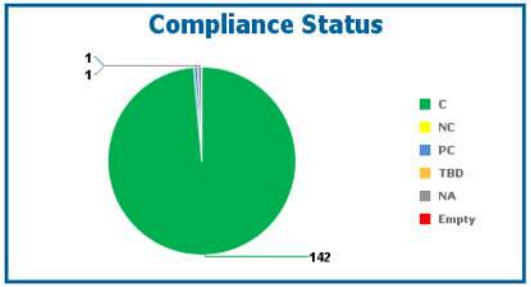
RMV Process - Quantify Progress

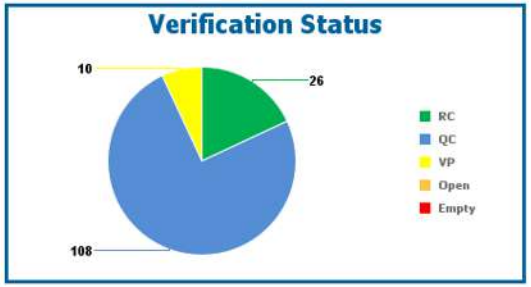
FUSION FOR ENERGY	Report Name	Senior Management Dashboard			
	Document Code	RMV.00.00.01			
	Refresh Date	03/06/2021 13:42		Page	1 of 2

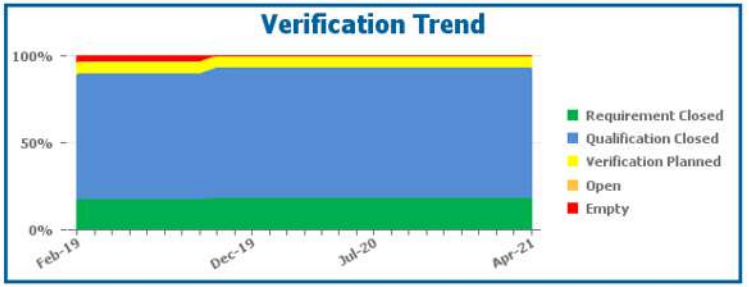
Senior Management F4E RMV Dashboard (PA activities)

		Requirements Baseline & Analysis	Requirements Propagation	Requirements Verification
Program 01	Project 01-01	99 %	100 %	45 %
	Project 01-02	93 %	0 %	0 %
	Project 01-03	63 %	0 %	0 %
Program 02	Project 02-01	88 %	76 %	55 %
	Project 02-02	100 %	100 %	11 %
	Project 02-03	95 %	95 %	50 %
	Project 02-04	100 %	100 %	49 %
	Project 02-05	100 %	99 %	71 %

	Documentation Baseline	Requirements Baseline	Analysis of Requirements	Requirements Propagation	Supplier Compliance	Contract Verification	PA Verification
Program 01	100%	100%	100%	99%	99%	80%	70%
Project 01-01				97%	99%	80%	







1. Introduction – The RMV Process

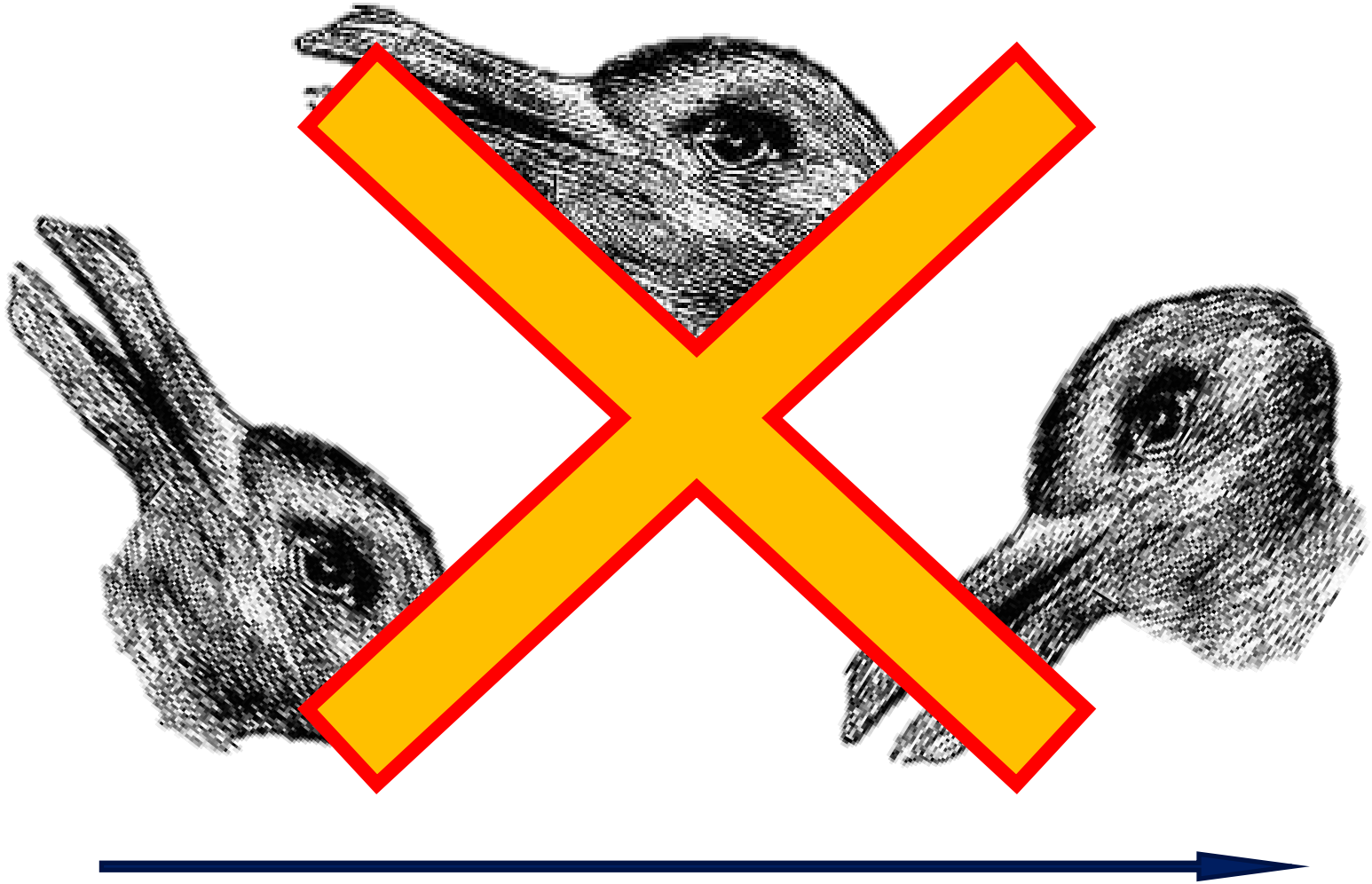


Image Source (URL): RabbitDuck

1. Introduction – The RMV Process

RMV Process - Quantify Quality

F4E Requirement Quality Report			
Template Version:	2.5	RQA Version:	18.4

Ontology Database	F4E_SESv18_ODB_Development	1.4
Knowledge Library	SOPHIST_INCOSE	1.4

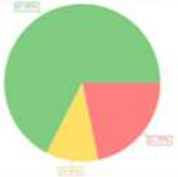
Quality Belt	1 MIR Quality: White Belt	1.4

Created by	Aldo Schaaf		
Date	18/05/2021	Time	17:30

Target Information:

DOORS Project	Project 01-01		
DOORS Module:	Project 01-01 TS		
IDM Tile	Project 01-01 Technical Specification		
IDM Reference	ABC123	IDM Version	v1.0

Correctness Quality Overview



Correctness	Absolute	Relative
Total *	212	100%
High	143	67%
Medium	23	11%
Low	46	22%
Not matching filters	0	0

* Number of Requirements with F4E Applicability

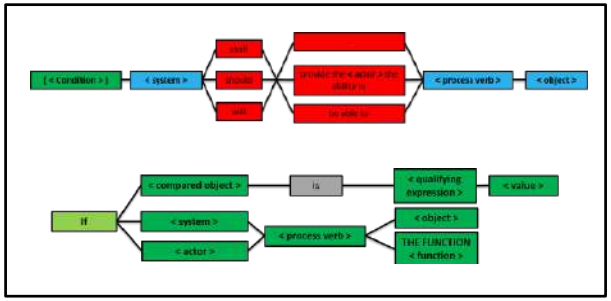
Metrics Quality Distribution

2. Traineeship Scope & Schedule

9 months

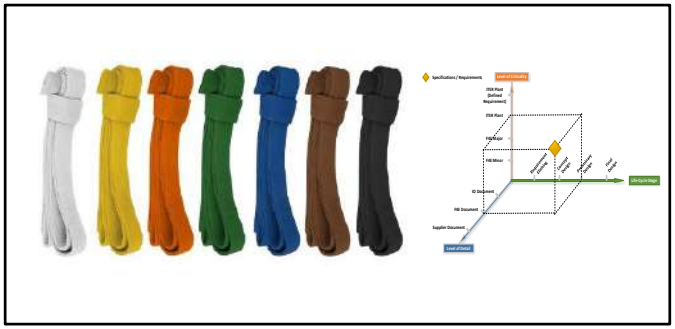
	Task Name	Duration
1	F4E_TRA_2020_091 - Aldo Schaaf	195 days
2	WP0 - Traineeship Management	195 days
7	WP1 - MASTeR Patterns	89 days
14	WP3 - SE Suite Implementation	80 days
41	WP2 - Quality Belts	117 days
55	WP4 - Assess Specification Quality using SES	31.4 days
59	WP5 - RQA2XL Quality Report Optimization	31 days
66	WP6 - RAT On-The-Fly Assessment	37.5 days

Systems Engineering Literature

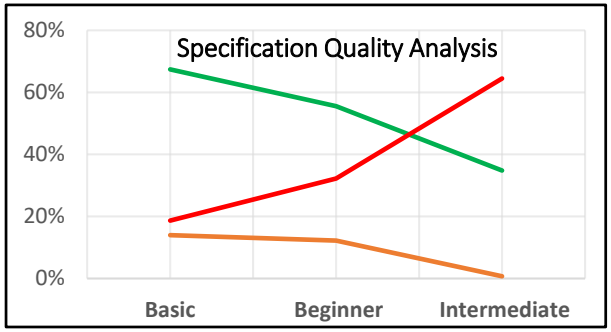


MASTeR Patterns by SOPHIST

Systems Engineering Suite (SES) by *The REUSE Company* (TRC)



Tailor the F4E Quality Belts



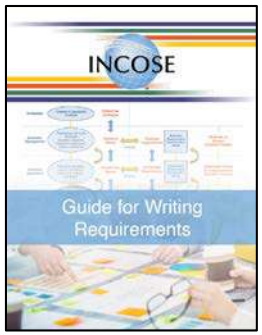
F4E Requirement Quality Report

3. Systems Engineering Literature

Requirement Quality – Knowledge Libraries

Documents: → **Knowledge Libraries**

- *Guide for Writing Requirements* (v3, 2019) by INCOSE Work Group
- *BIG EARS* (2010 paper) by Alistair Mavin
- *ECSS-E-ST-10-06C* (2009) by ECSS
- *A Short RE Primer* (1st edition, 2016) by The SOPHISTs
- *Schablonen für alle Fälle* (5. Auflage, 2019) by The SOPHISTs



ECSS Knowledge Library
Including the glossary, requirements patterns as rules as defined by the European Cooperation for Space Standardization

INCOSE Requirements Guide Knowledge Library
Focused mainly on the metrics defined as quality rules in the INCOSE Guide for Writing Requirements

EARS Knowledge Library
Including mainly the patterns described as requirements syntax in the Easy Approach to Requirements Syntax

SOPHIST Master Patterns Library
Include Master Patterns and 18 rules for Requirements Engineering

NASA Requirements Checklist Library
Including specific NASA vocabulary and concepts as well as quality rules to cover the checklist for good requirements.

Patterns | **Metrics** | **Glossary**

Quality Belts | **Ontology**

4. Requirement Patterns

Based on the SOPHIST "MASTeR Patterns" and corresponding TRC's Knowledge Library

FUSION FOR ENERGY

Legend: < ... > - Mandatory; [~ ... ~] - Optional

1. Functional Requirements

1.1. Independent Action

[~ Condition ~] | < system > | shall | < process verb > | < object >

"The time machine shall embed the Flux Capacitor."

1.2. User Interaction

[~ Condition ~] | < system > | shall | provide the | < actor > | the ability to | < process verb > | < object >

"The time machine shall provide the driver the ability to select the target date."

1.3. Third-Party Interaction

[~ Condition ~] | < system > | shall | be able to | < process verb > | < object >

"The time machine shall be able to provide 1.21 Gigawatt to the Flux Capacitor."

2. Non-Functional Requirements

2.1. Property

[~ Condition ~] | < characteristic > | < subject matter > | shall | be | [~ qualifying expression ~] | < value >

"The top speed of the time machine shall be at least 88 mph." *

2.2. Environment

[~ component of the ~] + < subject matter > | shall | be designed in a way that | [~ Condition ~] | < subject matter > | can be operated | < characteristic > | [~ qualifying expression ~] | < value >

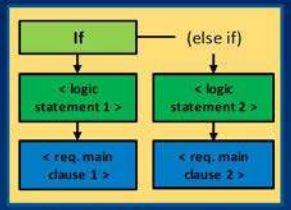
"The time machine shall be designed in a way that the time machine can be operated at an ambient temperature of -50 °C to +50 °C."

2.3. Process

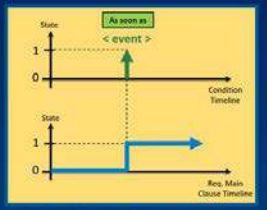
[~ Condition ~] | < actor > | shall | < process verb > | < object > | < value >

"The driver shall replace the fuse of the Flux Capacitor after every 10 time journeys."

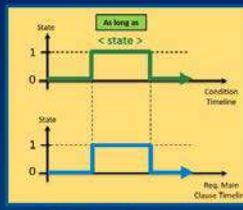
3. Conditional Statements



3.1. Logic Statement



3.2. Event Statement



3.3. Time Statement

3.1. Logic Statement

If | [~ characteristic ~] | < subject matter > | is | [~ qualifying expression ~] | < value >

If | < system / actor > | < process verb > | the function | < object > | < function >

"If the speed of the time machine is equal to 142 km/h, (...)"
"If the driver activates the function 'Manual Override', (...)"

3.2. Event Statement

As soon as | the event | < event > | happens

As soon as | < system / actor > | < process verb > | the function | < object > | < function >

"As soon as the event 'Emergency Shutdown' happens, (...)"
"As soon as the time machine detects a time-space singularity, (...)"

3.3. Time Statement

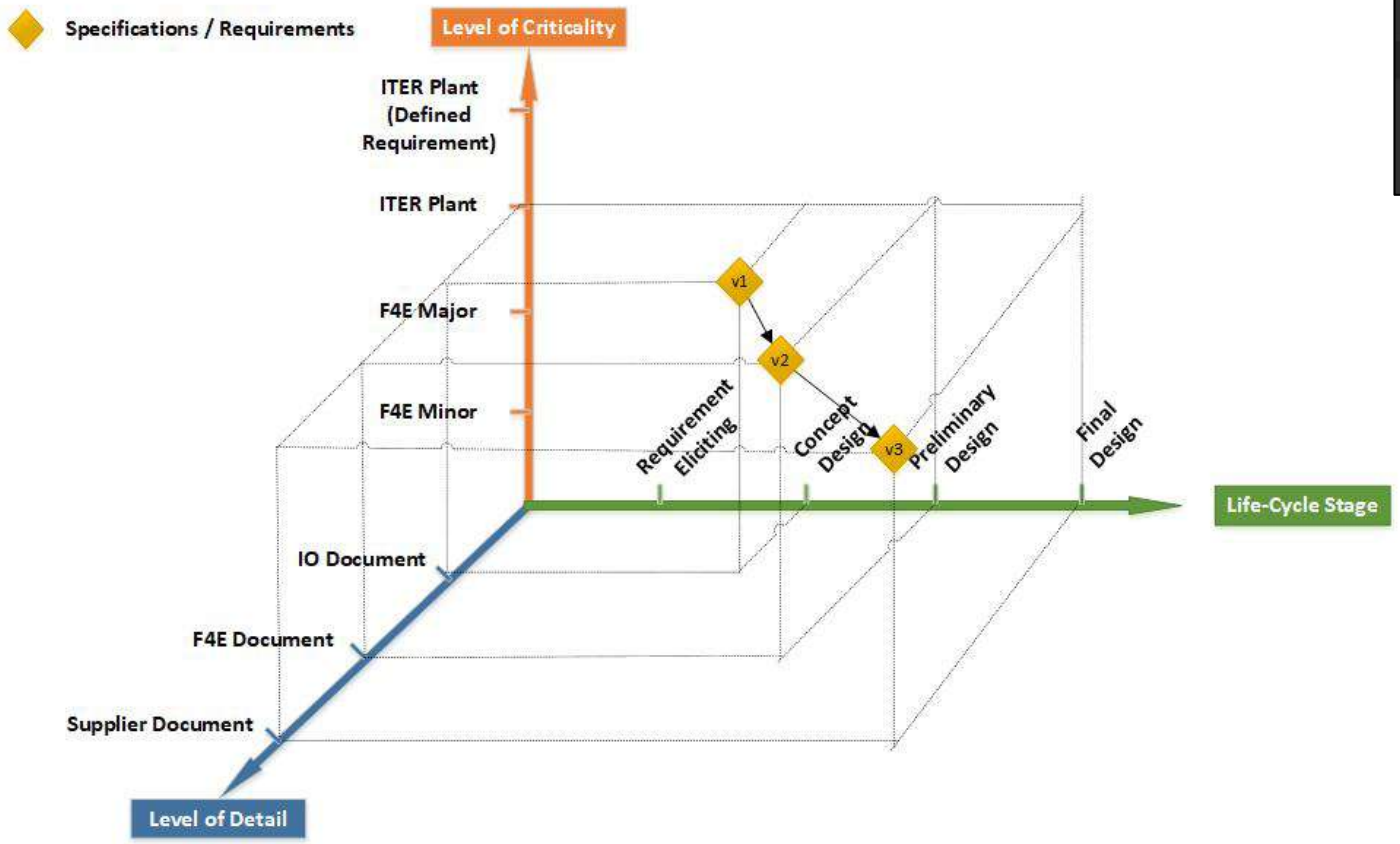
As long as | < system / object > | is in the state | < state >

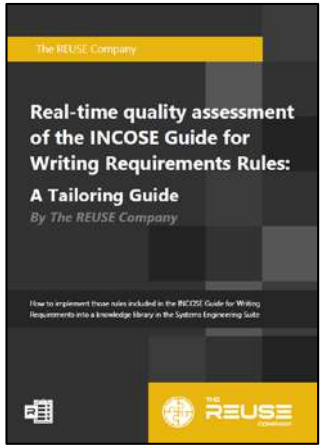
As long as | < system / actor > | < process verb > | the function | < object > | < function >

"As long as the time machine is in the state 'Air Travel', (...)"
"As long as the time machine detects an 'Unidentified Passenger', (...)"

5. Tailoring Quality Belts

3-Dimensional Requirement Quality Space





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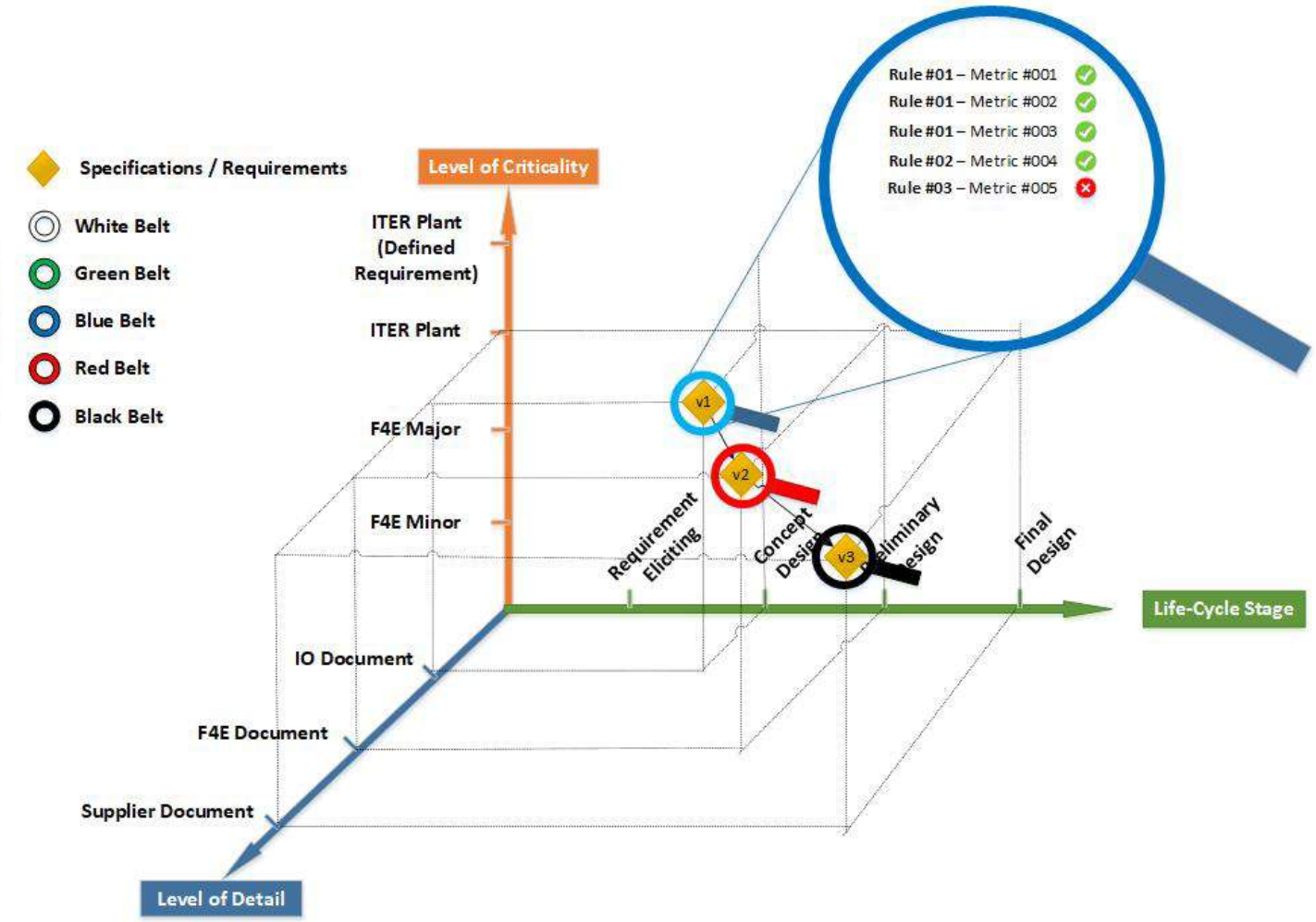
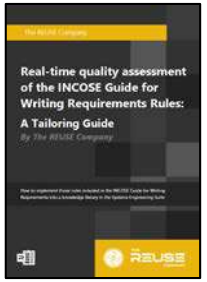
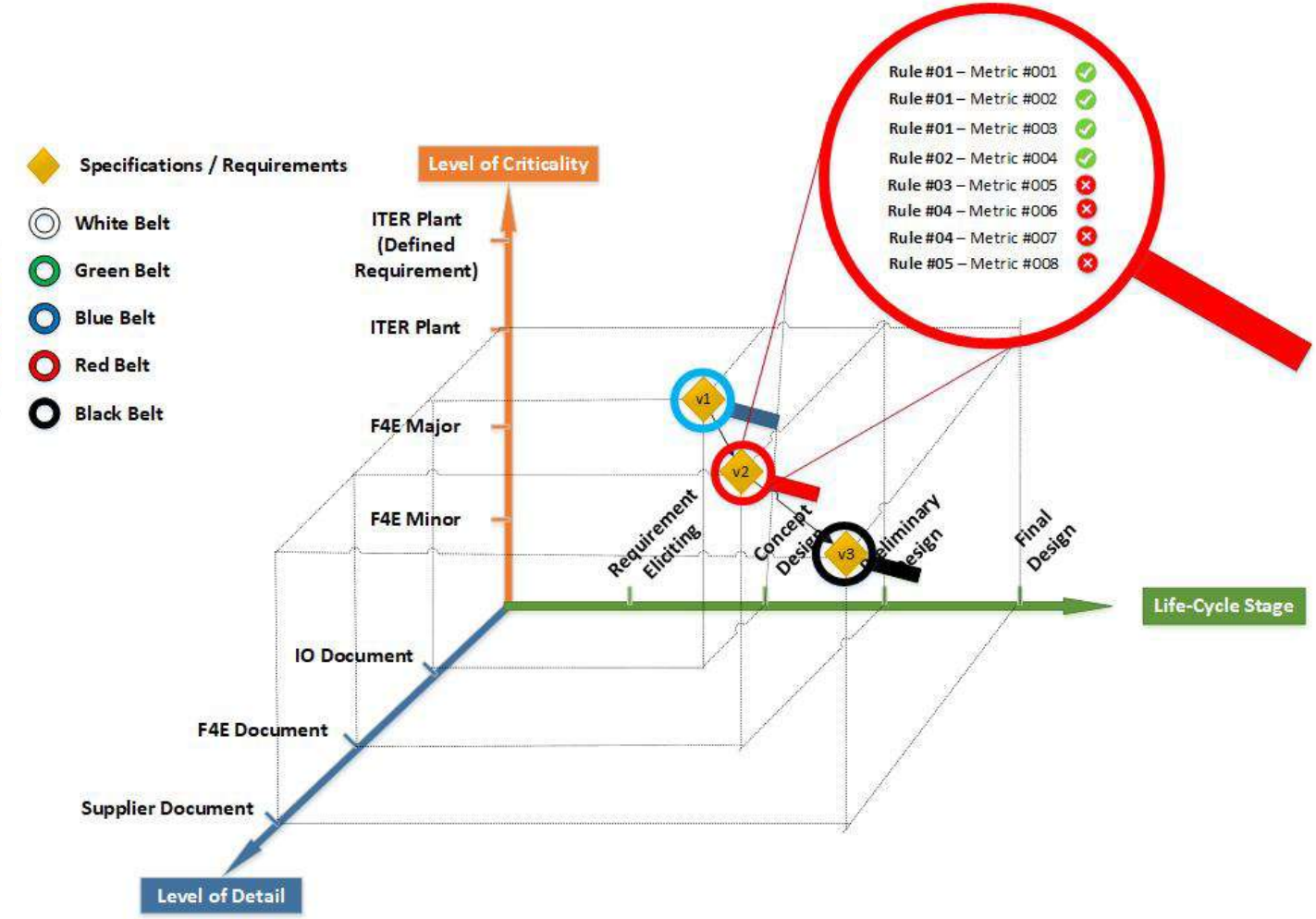
3-Dimensional Requirement Quality Space

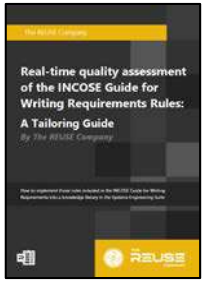




5. Tailoring Quality Belts

3-Dimensional Requirement Quality Space

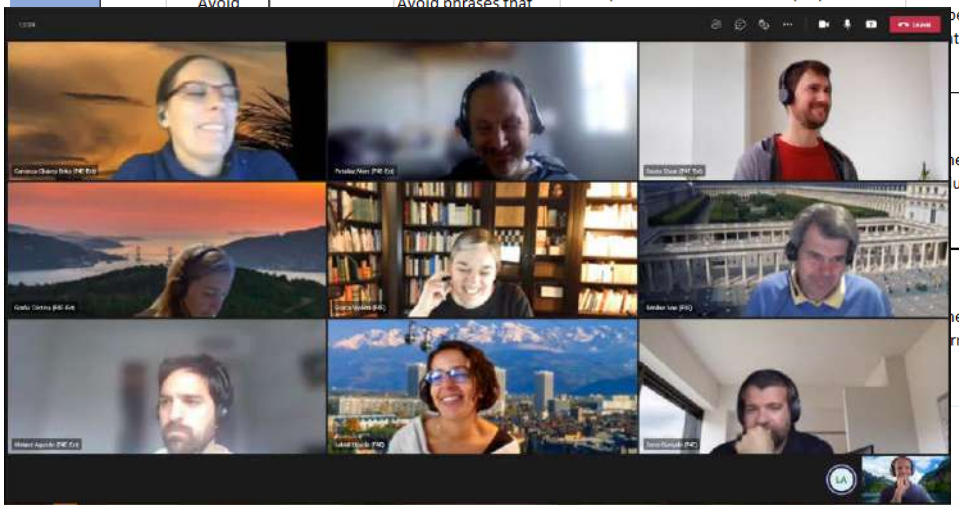




5. Tailoring Quality Belts

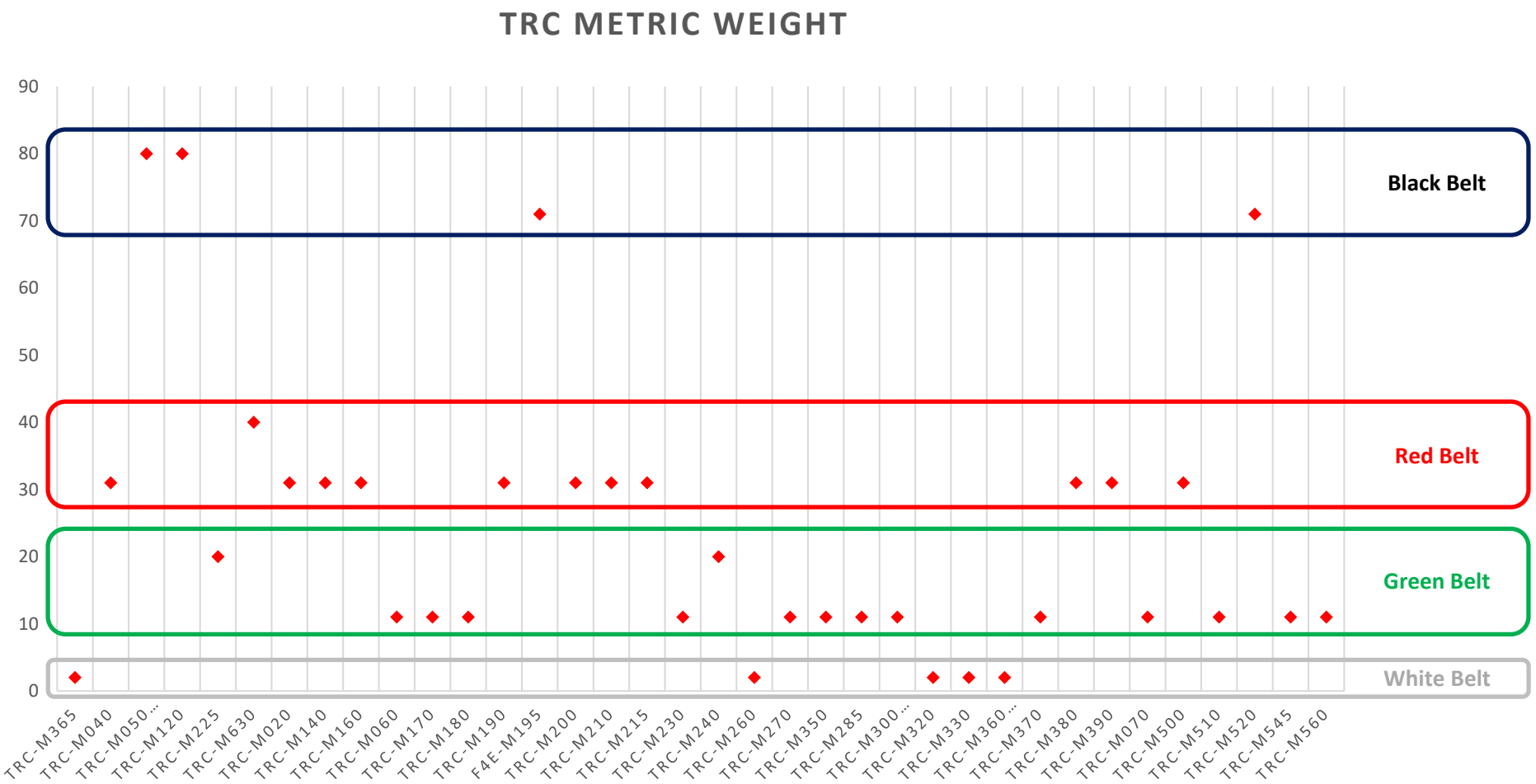
Workshop: Systems Engineering Group on Tailoring Quality Belts

INCOSE 2019 Rules			The REUSE Company					F4E Tailoring							
	37	# Rules	59	# Unique Metrics	(Mapped by TRC)	67	Vocabulary in KM	D1 - Level of Author				D2 - Maturity of Ontology			
T ID Type	INCOSE Rule	Rule Short Name	Metric Number	Metric Name	Rationale	Metric Type	Controlled Vocabulary / Last Updated	Basic 1	Beginner 10	Intermediate 30	Advanced 70	Poor 1	Rich 10	Metric Weight	Belt
T04 Singularity			TRC-M360 TRC-M360 [F4E]	Check the number of Modal Verbs	• This metric ensures that the requirement contains only one modal verb belonging to the cluster <MODAL VERB>.	Parameterized Term tag		1				1		2	White
	R19	Avoid Combinators	TRC-M370	Multiple subject detection	• This metric checks the use of a subject composed for more than one element in the requirement. • The metric uses a pattern group named <99 - METRIC - Multiple subject detector> to identify more than one noun before the modal verb.	Parameterized Pattern matching			1			1		11	Green
		Avoid		Avoid phrases that	• This metric controls the terms included in the special sentence list named <TRC-M380 - Avoid phrases that indicate the purpose>.	Parameterized pecial tences	**Forbidden Words:** in order to; justify; so that; thus; thus allowing; with the purpose of; with the / 3/17/2021			1		1		31	Red
						eterized uster				1		1		31	Red
						eterized rm tag	**Forbidden Words:** All; Another; Any; Anybody; Anybody else; Anyone; Anyone else; Anything; / 3/15/2021		1			1		11	Green



5. Tailoring Quality Belts

Workshop: Systems Engineering Group on Tailoring Quality Belts



5. Tailoring Quality Belts

Workshop: Systems Engineering Group on Tailoring Quality Belts

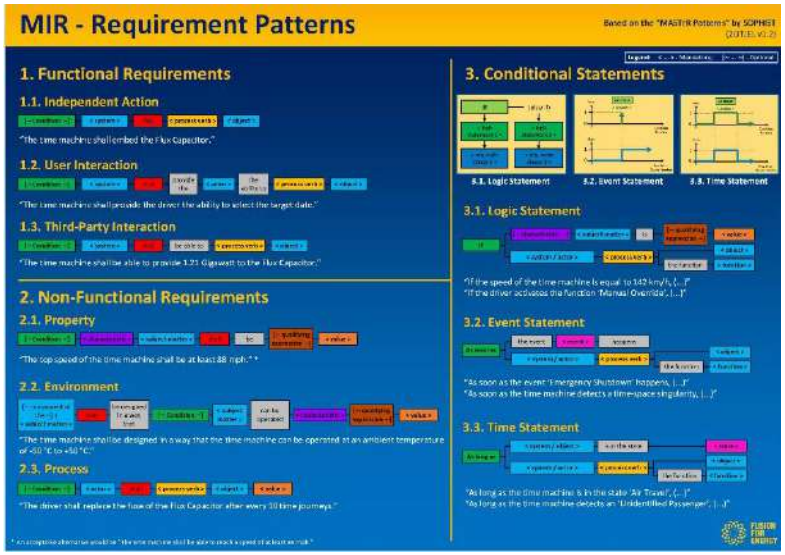
Quality Belt	Authoring Level	Correctness	Consistency	Completeness	Description	Examples
White	Basic	x			• Enforces the use of "shall" and checks for usage of banned modal verbs.	should, will, can, must
					• Checks for requirement length in terms of words (36) and paragraphs (3).	
Green	Beginner	x			• Checks if requirement is free of vague and forbidden terms.	manage, immediate, quickly, maximize
					• Checks if the requirement is free of pronouns.	any, all, every, it, that, this
					• Checks the use of proper grammar.	
					• Checks if requirement is free of negations and combinators outside of condition statements.	not, and, or, xor
Red	Intermediate	x	x		All checks of a White Belt, plus:	-
					• Avoid phrases that indicate a purpouse.	in order to, such that, justify
					• Checks if requirements are free of passive voice outside of condition statements.	the object shall be delivered at 17:00 (by whom?)
					• Checks if requirements are free of synonyms, unknown acronyms, unknown abbreviations and indefinite articles.	
					• Checks if requirements are free of indefinite articles.	a, an
					• Checks if numbers are followed by units , if units match the characteristic they quantify and the use of consistent measurment systems.	
					• Avoid open-ended expressions, escape sentences and the use of parenthesis.	etc, when possible, included but not limited to, among others, ...
Black	Advanced	x	x	x	All checks of the White and Green Belt, plus:	-
					• Enforces the use of the MIR Requirement Patterns.	
					• Checks for overlapping requirements.	
					• Checks if subject belongs to recognized "Actors" and if it is at an adequate level of the PBS.	
					• Checks if main verbs belong to controlled "Process Verbs".	
					• Checks if requirements are free of "TBx" expressions.	TBD, TBC, to be confirmed

Generic

Specific

5. Tailoring Quality Belts

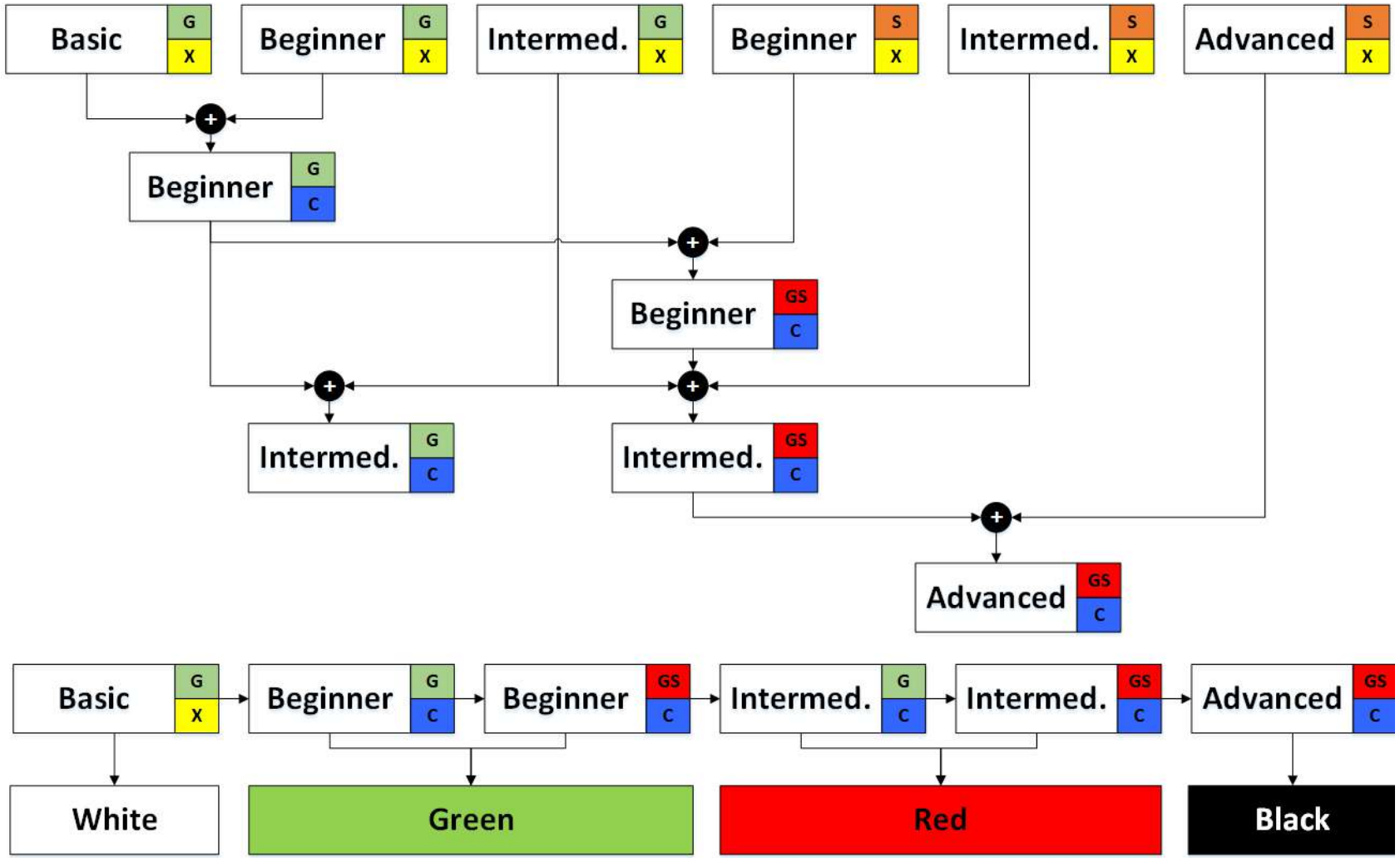
Quality Belts vs. Requirement Patterns



Requirement Patterns **available** to the requirement author **from the start**.

Requirement Patterns **enforced** to the requirement author **at advanced belt**.

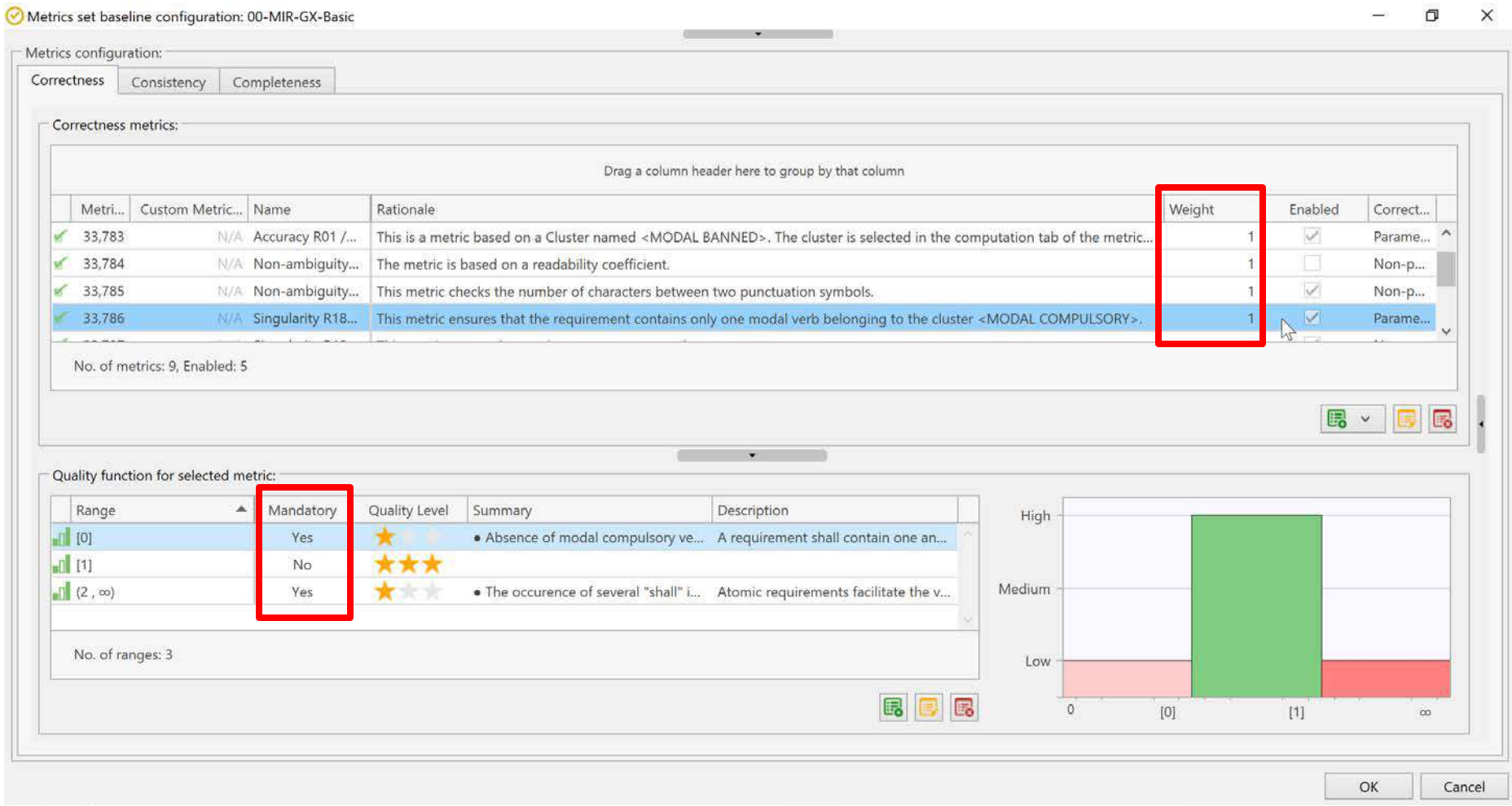
5. Tailoring Quality Belts



G → Generic Ontology | S → Specific Ontology (Domain) | GS → Generic + Specific Ontology | X → Exclusive Metric Set Baseline | C → Compound Metric Set Baseline (Union)

5. Tailoring Quality Belts

Metrics Weight vs Mandatory Metrics



6. Methodology

Based on Metrics Weight

[A]

- **Batch [A-]:** The weights of metrics belonging to previous belts have weight 2 wrt. to metrics of current belt.
- **Batch [A+]:** The weights of metrics belonging to next belts have weight 2 wrt. to metrics of previous belt.

[B]

- **Batch [B-]:** Metrics belonging to Basic belt weigh 3, Beginner belt weigh 2 and Intermediate belt weigh 1.
- **Batch [B+]:** Metrics belonging to Basic belt weigh 1, Beginner belt weigh 2 and Intermediate belt weigh 3.

[C]

- **Batch [C-]:** Metrics belonging to Basic belt weigh 10, Beginner belt weigh 5 and Intermediate belt weigh 1.
- **Batch [C+]:** Metrics belonging to Basic belt weigh 1, Beginner belt weigh 5 and Intermediate belt weigh 10.

[E]

- **Batch [E-]:** Metrics belonging to Basic belt weigh 100, Beginner belt weigh 10 and Intermediate belt weigh 1.
- **Batch [E+]:** Metrics belonging to Basic belt weigh 1, Beginner belt weigh 10 and Intermediate belt weigh 100.

Based on Mandatory Metrics

[D]

- **Batch [D]:** The metrics belonging to previous belts are set to mandatory.

6. Methodology

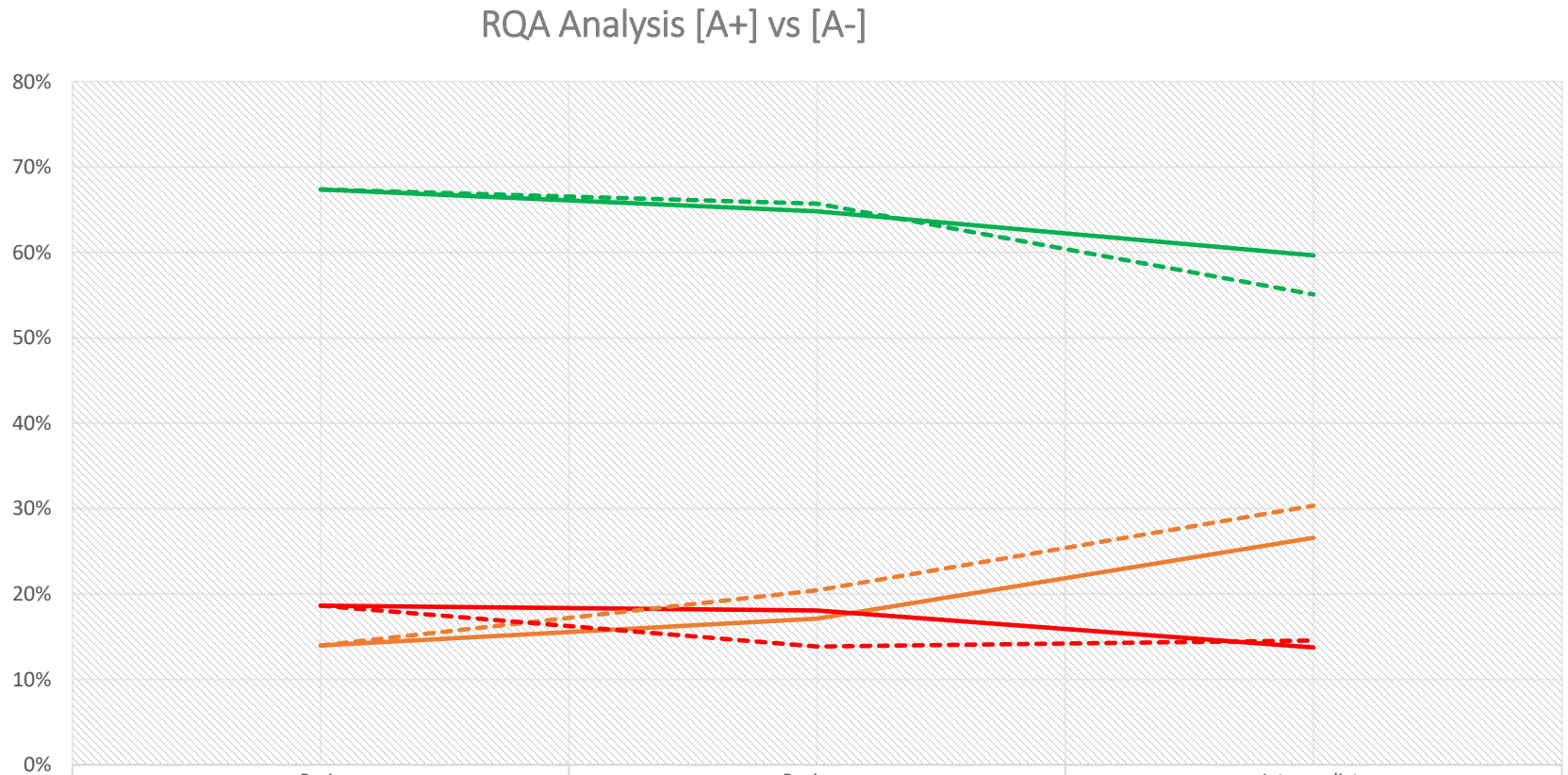
Technical Specifications - Sample

» The ... shall ...

Program Teams	Technical Specifications	Technical Requirements
6	13	2500+

7. Results

[A]



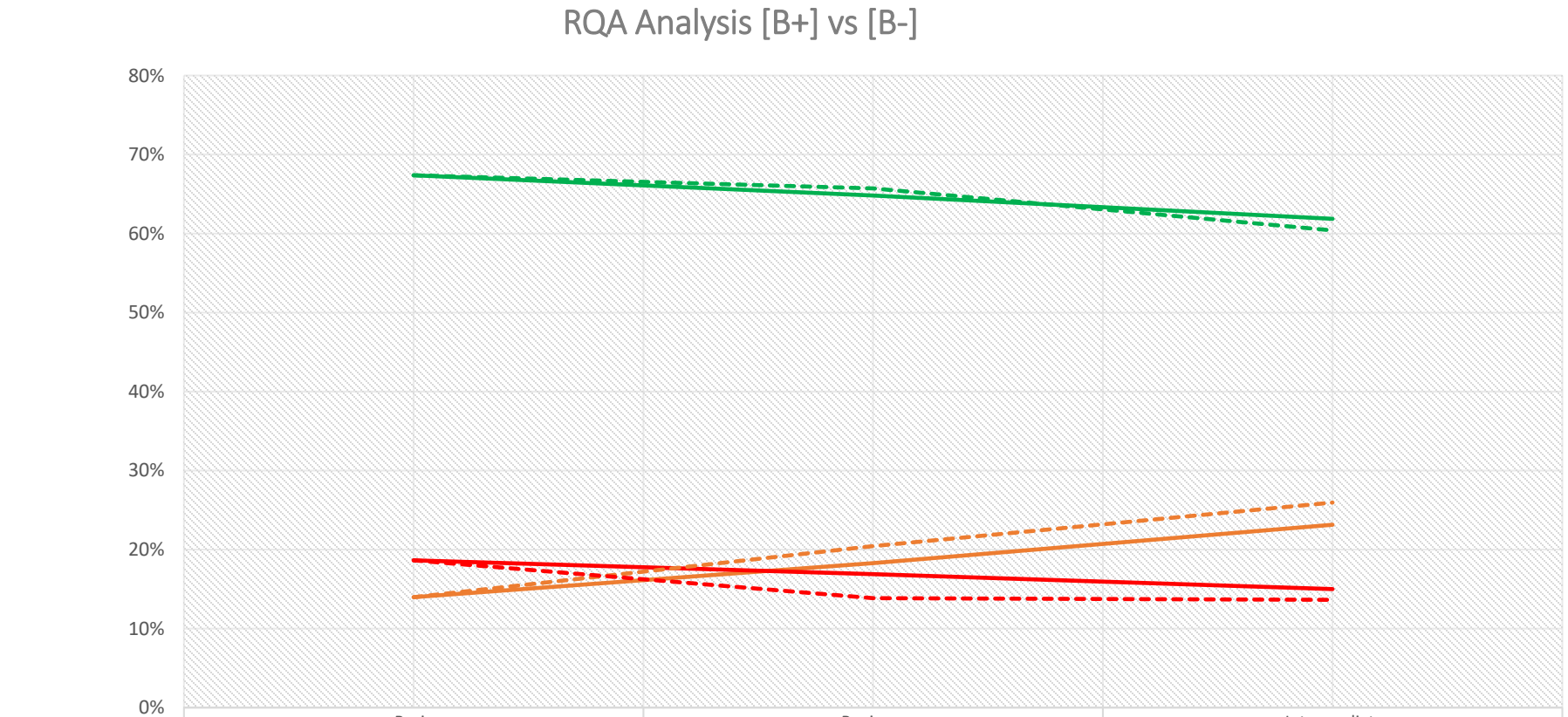
	Basic	Beginner	Intermediate
High (A-)	67%	65%	60%
Medium (A-)	14%	17%	27%
Low (A-)	19%	18%	14%
High (A+)	67%	66%	55%
Medium (A+)	14%	20%	30%
Low (A+)	19%	14%	15%

Metrics Set Baseline

Batch [A-]: The weights of metrics belonging to lower quality levels have weight 2 wrt. to metrics of current quality level.
Batch [A+]: The weights of metrics belonging to current quality level have weight 2 wrt. to metrics of lower quality levels.

7. Results

[B]

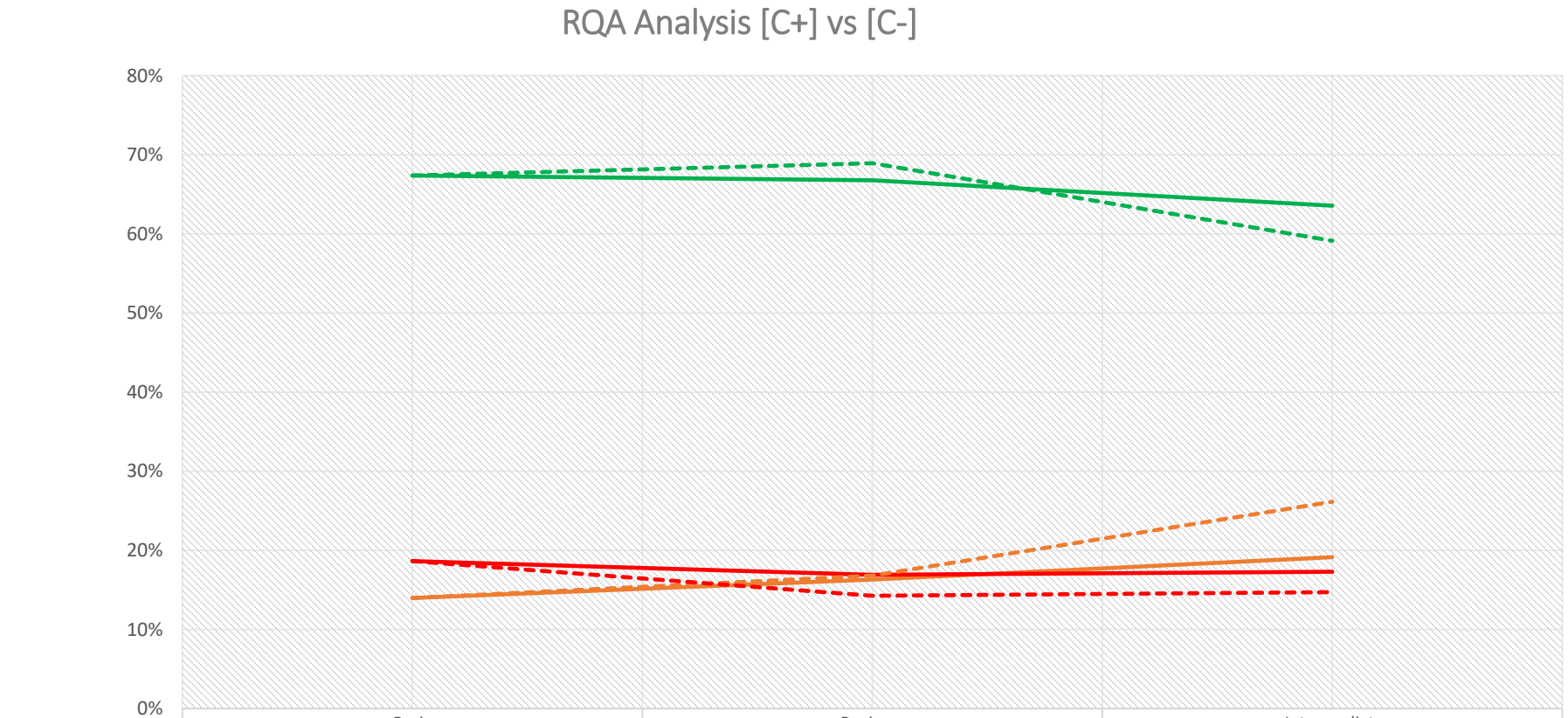


	Basic	Beginner	Intermediate
High (B-)	67%	65%	62%
Medium (B-)	14%	18%	23%
Low (B-)	19%	17%	15%
High (B+)	67%	66%	60%
Medium (B+)	14%	20%	26%
Low (B+)	19%	14%	14%

Batch [B-]: Metrics belonging to Basic belt weigh 3, Beginner belt weigh 2 and Intermediate belt weigh 1.
Batch [B+]: Metrics belonging to Basic belt weigh 1, Beginner belt weigh 2 and Intermediate belt weigh 3.

7. Results

[C]



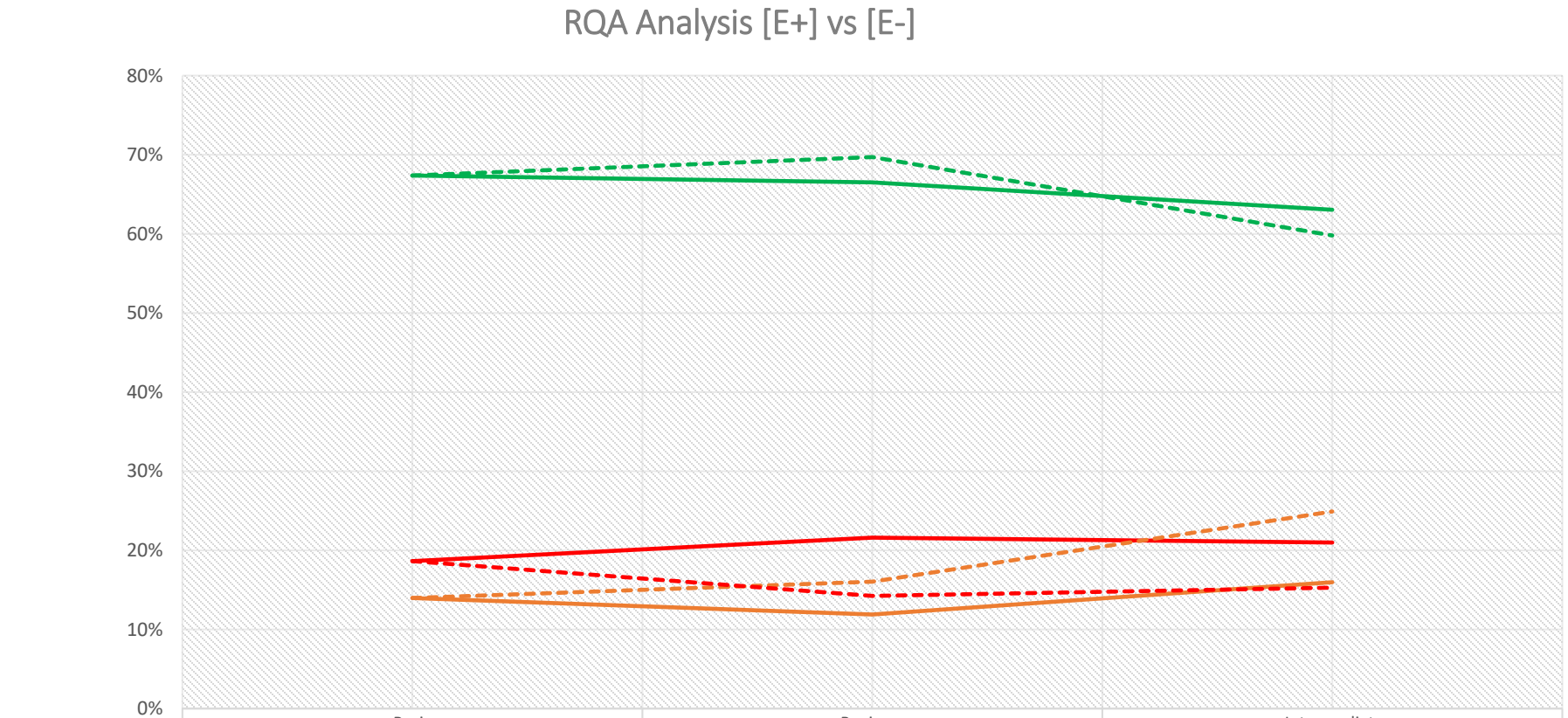
	Basic	Beginner	Intermediate
High (C-)	67%	67%	64%
Medium (C-)	14%	16%	19%
Low (C-)	19%	17%	17%
High (C+)	67%	69%	59%
Medium (C+)	14%	17%	26%
Low (C+)	19%	14%	15%

Metrics Set Baseline

Batch [C-]: Metrics belonging to Basic belt weigh 10, Beginner belt weigh 5 and Intermediate belt weigh 1.
Batch [C+]: Metrics belonging to Basic belt weigh 1, Beginner belt weigh 5 and Intermediate belt weigh 10.

7. Results

[E]



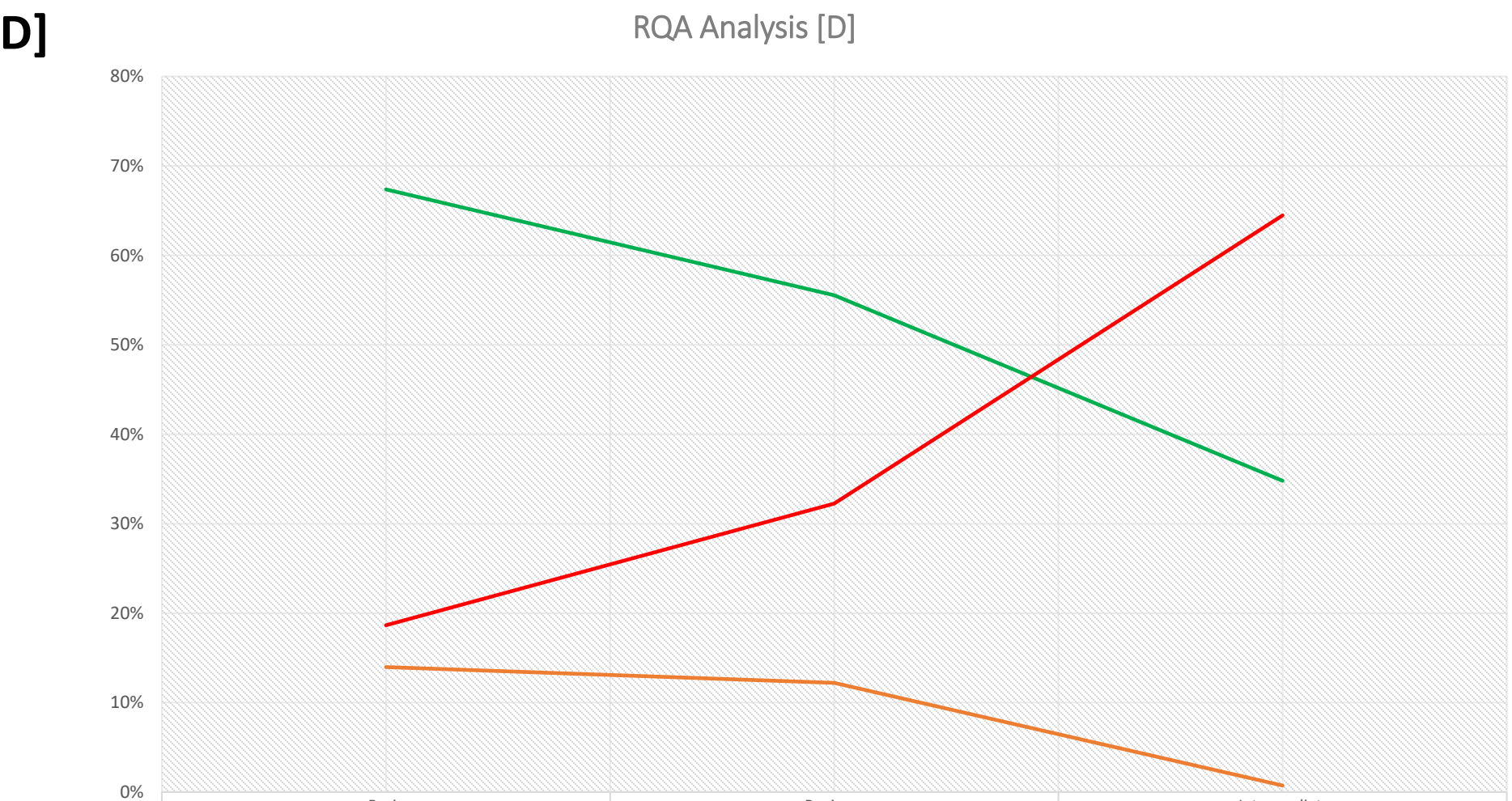
	Basic	Beginner	Intermediate
High (E-)	67%	67%	63%
Medium (E-)	14%	12%	16%
Low (E-)	19%	22%	21%
High (E+)	67%	70%	60%
Medium (E+)	14%	16%	25%
Low (E+)	19%	14%	15%

Metrics Set Baseline

Batch [E-]: Metrics belonging to Basic belt weigh 100, Beginner belt weigh 10 and Intermediate belt weigh 1.
Batch [E+]: Metrics belonging to Basic belt weigh 1, Beginner belt weigh 10 and Intermediate belt weigh 100.

7. Results

[D]

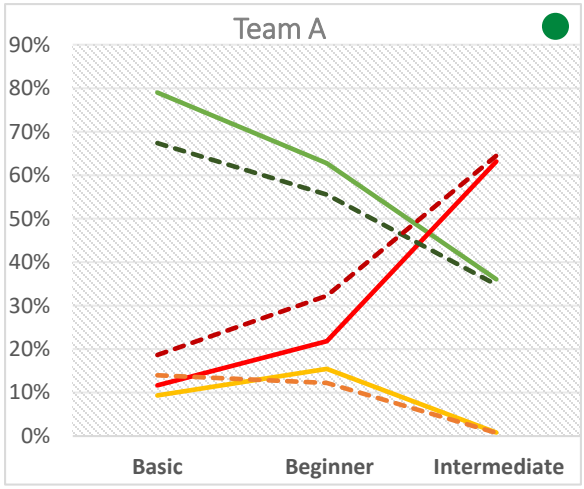


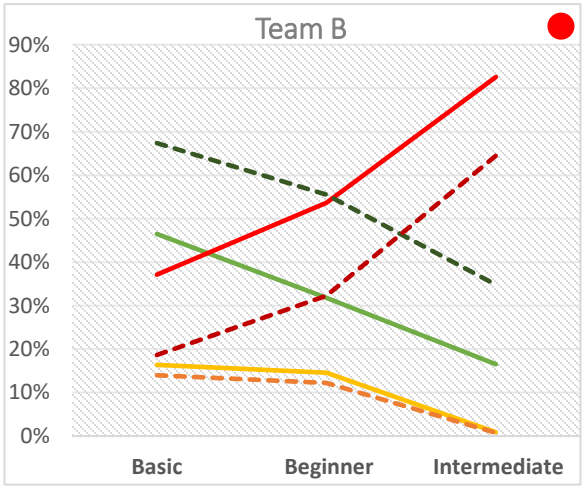
Batch [D]: The metrics belonging to lower quality levels s are set to mandatory.

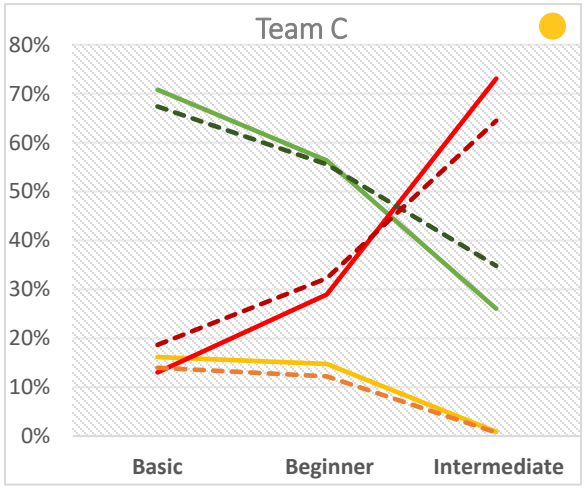
7. Results

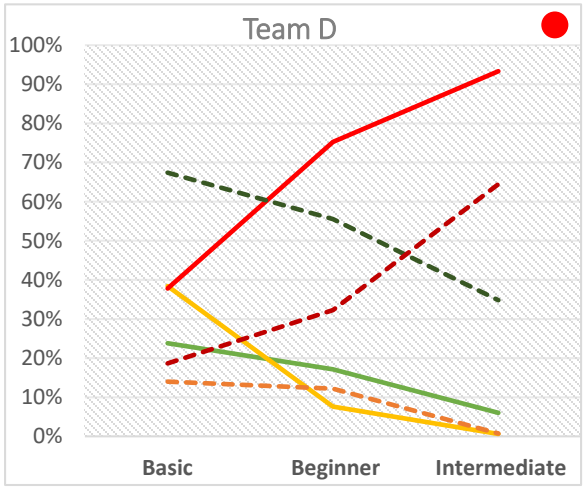
[D]

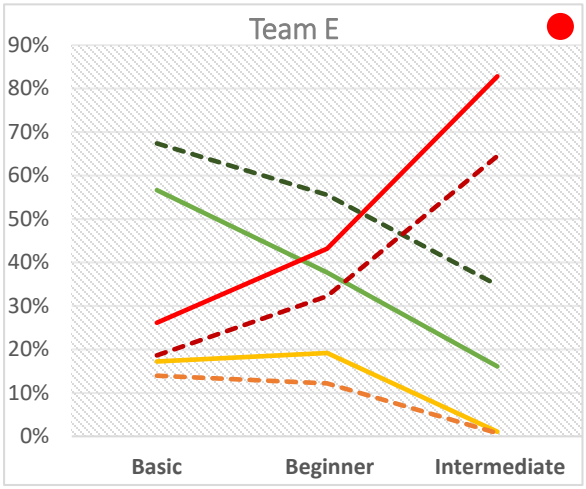

Project Team
Average
High
Medium
Low
Above average
Close to average
Below average

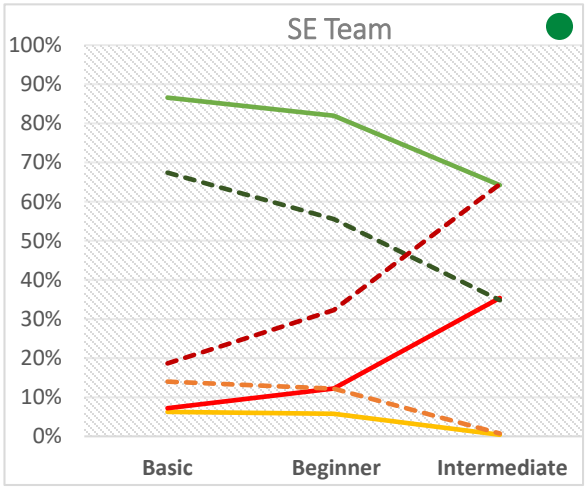

Team A
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Basic
Beginner
Intermediate


Team B
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Basic
Beginner
Intermediate

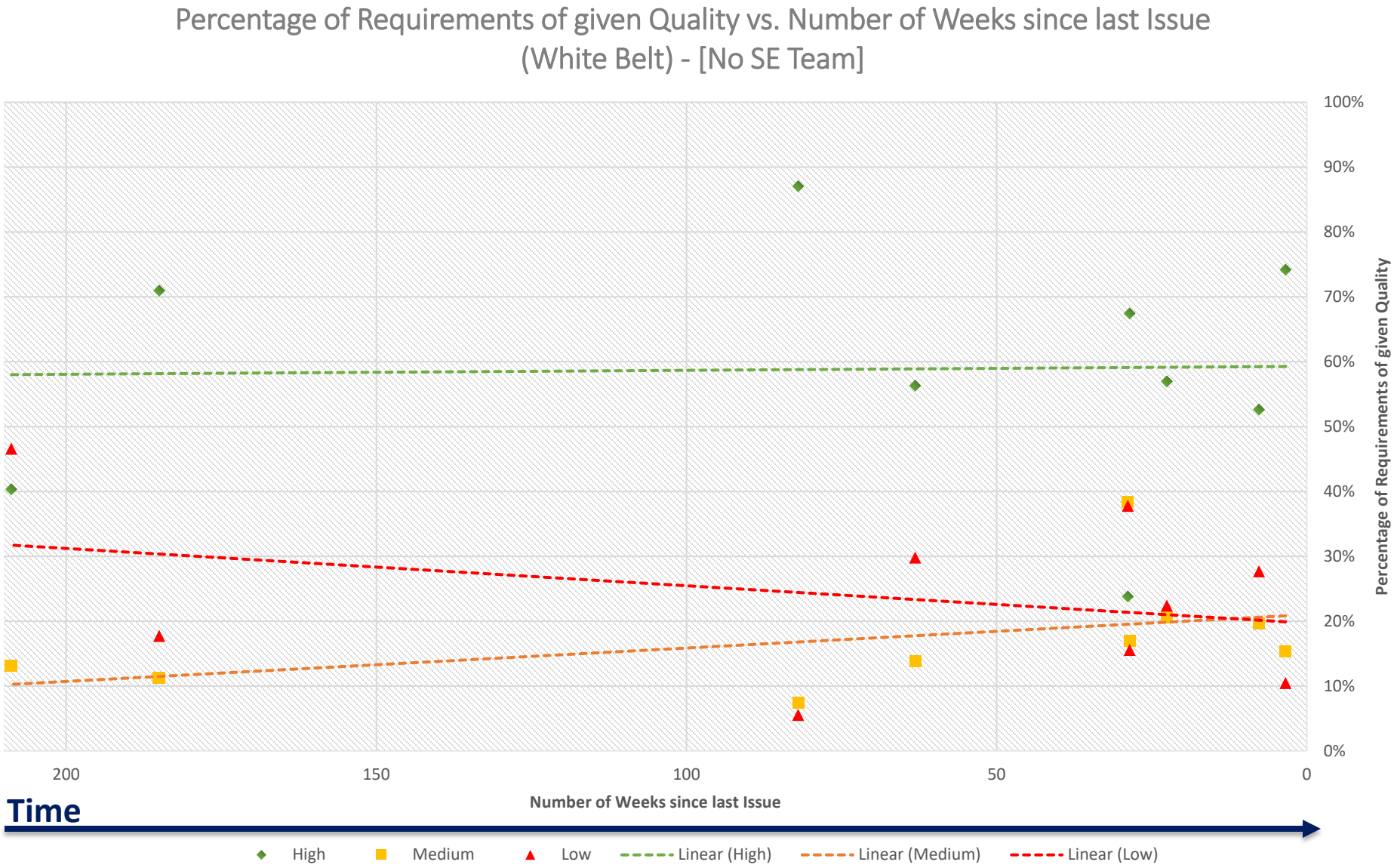

Team C
80%
70%
60%
50%
40%
30%
20%
10%
0%
Basic
Beginner
Intermediate


Team D
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Basic
Beginner
Intermediate

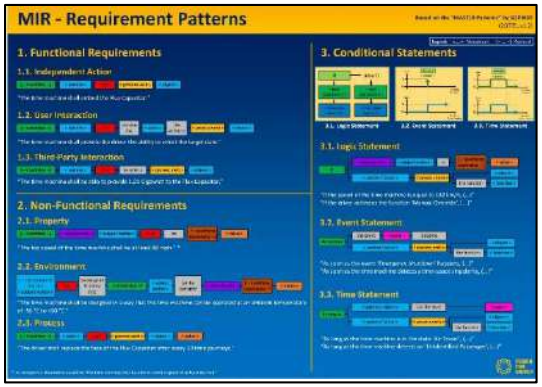

Team E
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Basic
Beginner
Intermediate


SE Team
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Basic
Beginner
Intermediate

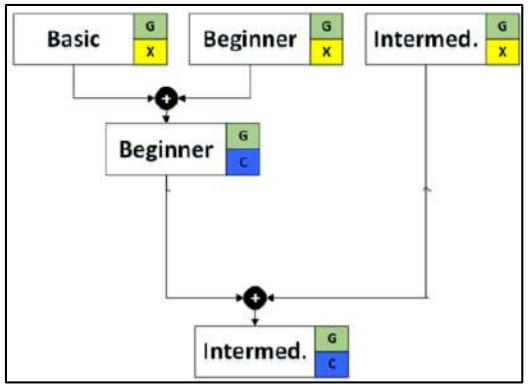
7. Results


Percentage of Requirements of given Quality vs. Number of Weeks since last Issue (White Belt) - [No SE Team]
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Requirements of given Quality
200
150
100
50
0
Number of Weeks since last Issue
Time
High
Medium
Low
Linear (High)
Linear (Medium)
Linear (Low)

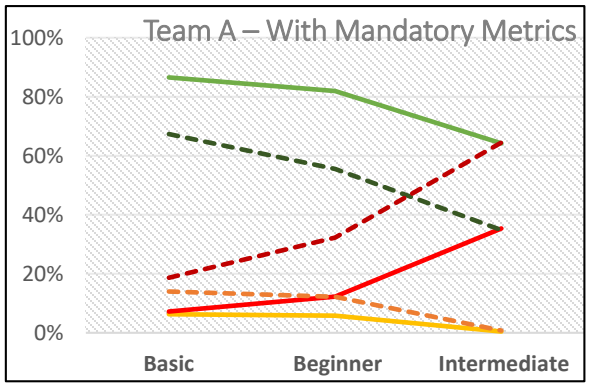
8. Conclusion



Make the Requirement Patterns available as soon as possible.



Requirement Quality Belts can be managed as union of exclusive metric set baselines in RQA.



Metrics belonging to lower quality belts to be set as mandatory in higher quality belts.

Future Work:

- Develop Domain Specific Ontologies;
- Familiarize more project teams with the Systems Engineering Suite;
- Increase specification sample to assess evolution of requirement quality over time;

Thank you for your attention

3. Deployment of SE Suite

Local Testing and Development Deplyoment

F4E Laptop

Licensing

FlexNet
(v11.14.1.0)

TRC Vendor Daemon
(v18.4)

TRC Token Manager
(v18.4)

SES Management

SES Server
(v18.4)

RQA Batch
(v18.4)

SES Db Migration Tool
(v18.4)

SES Clients

KM
(v18.4)

RQA
(v18.4)

RAT
(v18.4)

RAT Plugin for DOORS
(v18.4)

Workproduct DB Server

IBM Rational DOORS
(9.6)

Ontology DB Server

Microsoft SQL Server Express
(2012 SP4)

3. Deployment of SE Suite

Production Deployment

F4E Ontology DB Server

F4E SES Server

F4E Remote Desktop

F4E Laptop

F4E DOORS DB Server

Ontology DB Server

Microsoft SQL Server
(2012 SP4 Enterprise Edition)

Licensing

FlexNet
(v11.14.1.0)

TRC Vendor Daemon
(v18.4)

TRC Token Manager
(v18.4)

SES Management

SES Server
(v18.4)

RQA Batch
(v18.4)

TRC Db Migration Tool
(v18.4)

SES Clients

End-User Type: SESO

KM
(v18.4)

RQA
(v18.4)

RAT + RAT Plugin for DOORS
(v18.4)

End-User Type: Author

RAT Plugin for DOORS
(v18.4)

Workproduct DB Server

IBM Rational DOORS
(9.6)