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Contract-Based Requirements Engineering

Third International Workshop on
Requirements Engineering and Law

In conjunction with the 18th IEEE International
Requirements Engineering Conference



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Why is contract-based RE Important?

Mistakes can be very costly \$\$\$

There are *significant* differences when the work is contract-based:

- The tracing model
- Project execution requirements
- Constraints
- Cross-cutting requirements
- Regulatory codes and standards
- Contract options
- Penalty clauses
- Incentive payments
- Requirements analysis processes
- Contract compliance
- Subcontractor work packages



But almost no one publishes on it!

Requirements Engineering related literature:

Proceedings of International Conference on Requirements Engineering
Proceedings of International Workshop on Requirements Engineering Foundation of Software Quality (REFSQ)
Requirements Engineering Journal
Proceedings of International Workshop on Requirements Engineering and Law

Software Engineering related literature:

International Conference on Software Engineering (ICSE)
International Conference on Machine Learning and Applications (ICMLA)
International Conference on Artificial Intelligence and Law (ICAAIL)
International Conference on Global Software Engineering (ICGSE)
International workshop on Mining Software Repositories at ICSE
International Workshop on Software Engineering in Healthcare at ICSE (SEH)
World Congress on Engineering & Computer Science (WCECS)
International Workshop on Traceability in emerging Forms of Software Engineering at ICSE
International Workshop on Software Engineering for Secure Systems at ICSE
International Conference on Machine Learning and Computing (ICMLC)
Transactions on Software Engineering Journal
Empirical Software Engineering Journal
Information and Software Technology Journal
Software Quality Journal

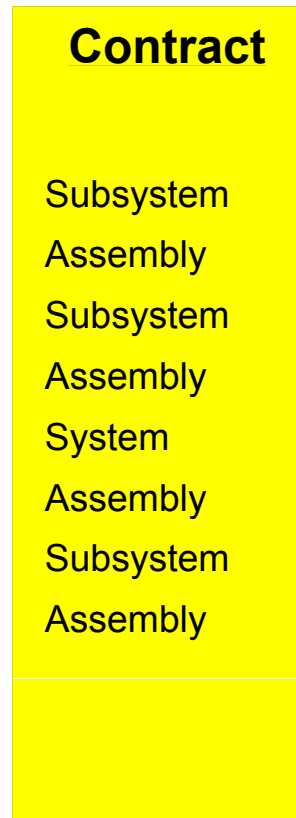
Systems engineering related:

International Symposium on Systems Engineering (INCOSE Int'l Symposium)
Systems Engineering Journal (SEJ)
Journal of Systems Science and Systems Engineering (JSSSE)
All possible issues/proceedings available online + INCOSE proceedings



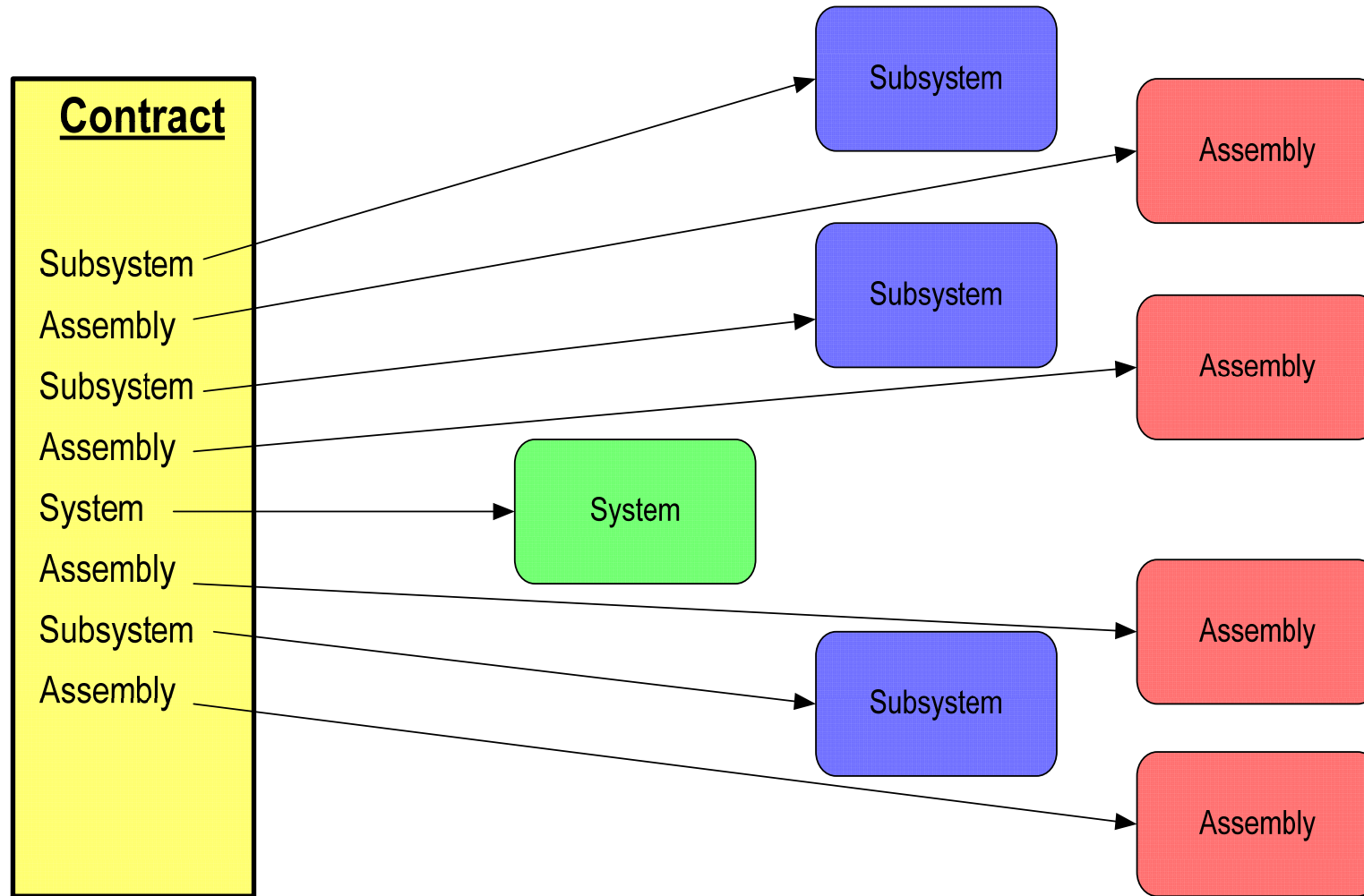
~3 HITS!

Tracing - Customer Requirements replaced by Contract

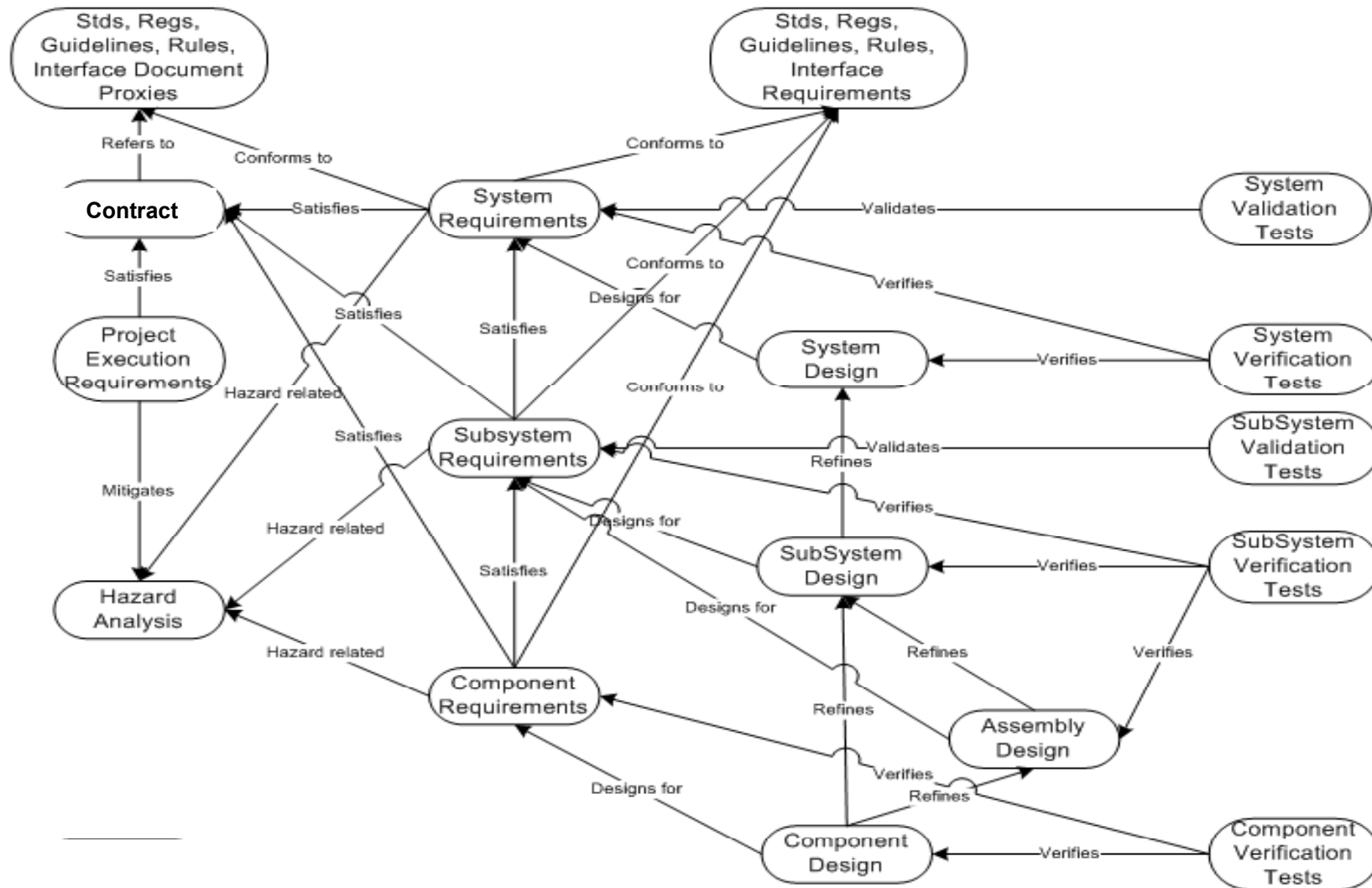


- The contract is binding
- Contains mixed requirements at many levels
- May include elements of design

Trace Model - Example



A Contract-Based Tracing Model - Example



Project Execution Requirements

Project execution requirements can be extraordinarily challenging to manage on a project.

They may impact all aspects of a project including:

- Milestones & Project Plans
- Work Packages
- Verification & Validation
- Quality Assurance Activities



Project Execution Requirements - Examples

PE Requirement	Impacts
“Designs shall be approved by the customer before orders are placed for equipment.”	Project Milestones And Scheduling
“Piping shall be buried to a depth of six feet in a sand bed”	Work Package And Test Plans
“Design reviews shall be conducted in accordance with IEEE 1220.”	Quality Assurance Plan And Process
“The customer shall approve the final selection of the candidate for Quality Assurance Management”	Project Staffing And Resources
“All work shall be warranted for a period of three years.”	Budget And Staffing

Constraints

- ❑ Constraints are requirements that narrow or define the scope of a solution.
- ❑ They are typically kept in a section specific to constraint requirements.

-Example –

“Exterior metal surfaces for all structures shall be painted with Benjamin Moore M24-80 P paint.”



Cross-cutting requirements

Cross-cutting requirements are those requirements that span multiple systems or subsystems

They may be functional:

“All electronic components shall be self-diagnosing and provide an interface to external systems to report on their status”.

or non-functional:

“All delivered systems and components that are intended for outdoor use shall be waterproof.”

Or project execution requirements:

“All designs shall be approved by the customer before construction can start.”





The Challenge of Cross-cutting Requirements

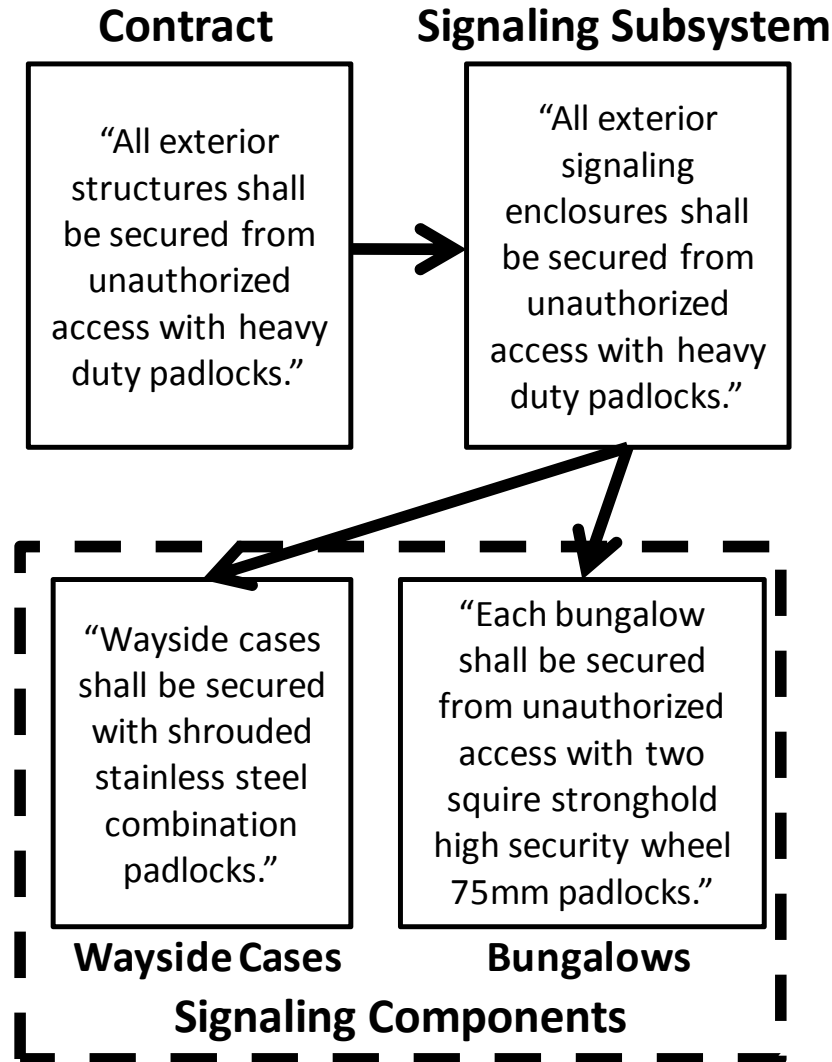
- Maintain in one place
- Manage changes
- Identify impact on other project requirements
- Ensure that subcontractors and workers are aware of them, e.g. included in work packages



Cross-cutting Requirements – Best Practice

- Trace down
- Replicate and customize

Note: They will be passed on to subcontractors in work packages



Special Categories of Requirements

❑ **Regulatory Requirements** (e.g. New York Electrical Safety Code)

❑ **Standards** (e.g. IEEE 1220)

❑ **Project execution requirements**

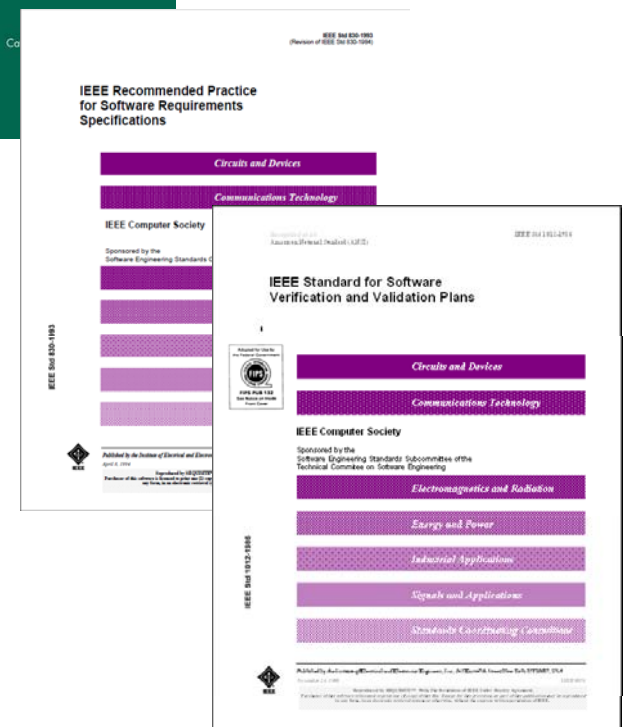
- Submittals (Plans, Manuals, Drawings)
- Things to do (Installation, Commissioning, Pay fees, etc.)
- Long Term Obligations (Service, Maintenance, Spare parts, Warranty)
- Staffing (Prequalify Project Leads, Specify Functions)



Regulatory Codes & Standards

Regulatory Codes are sets of requirements that implement government policy

- They may impact processes or deliverables
- They are published by nonprofit organizations or government agencies
- They are legally binding
- There may be legal and/or criminal penalties for failing to follow them.
- Regulatory guidelines are suggestions that do not have to be followed unless specifically called out in a contract.
- Technical standards are sets of established norms or requirements. Like guidelines, they do not have to be followed unless required by the contract.



Challenges of Regulatory Codes

□ Regulatory codes may be Explicit

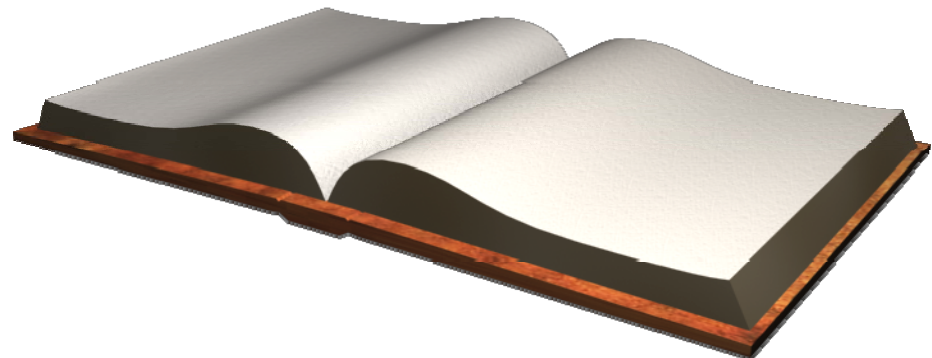
- Explicit regulatory codes are specified in the requirement.

“The system shall conform to AREMA Communications & Signal Manual, Part 2.2.12 - Recommended Functional/Operating Guidelines for Interlocking Systems”

□ Regulatory Codes may be Implicit

- Implicit regulatory codes do not specify what is applicable or where the impact is. Note that some codes may be over 1000 pages.

“The supplier shall be fully familiar with and comply with applicable laws, applicable environmental acts, regulations and municipal by-laws for environmental requirements.”



Regulatory Codes - Example

Microsoft Excel - Regulatory Requirements_AA.xls											
Type a question for help											
Description											
	A	B	C	D	E	F	G	H	I	J	K
1	REGULATORY REQUIREMENTS due to Contract RFP-2005-GT-009 (Book 2/5, Section 01410)										
2											
3	No.	Contractual structure	Name	Description	Edition/ Year (most recent)	Publisher	Source	Pages	Costs (CAD)	NMS	Signa
4	2.1 Government of Canada										
5	1	2.1.1	Railway Safety Act	RSA including Railway Signal & Traffic Control Systems Standard	2007	Transport Canada	Link		0.00		
6	2	2.1.2	Canadian Rail Operation Rules (CROR)	Specified requirement for signal aspects incl. Advanced Clear to Medium	2008	RAC		107	0.00		
7	3	2.1.3	Canadian Electrical Code		2009 (21st edition)	CSA	Link	640	150.00		
8	4	2.1.4	National Building Code of Canada		2005	NRCC	Link	1167	190.00		
9	5	2.1.5	National Fire Code of Canada		2005	NRCC	Link	349	130.00		
10	6	2.1.6	National Plumbing Code of Canada		2005	NRCC	Link	231	110.00		
11	7	2.1.7	Canadian Environmental Protection Act		1999		Link		0.00		
12	8	2.1.8	Canadian Environmental Assessment Act		1992		Link		0.00		
13	9	2.1.9	Canada Labour Code Part II		updated 2008		Link		0.00		
14	10	2.1.10	WHMIS Regulations	Occupational Health and Safety Act	updated 2007		Link		0.00		
15	11	2.1.11	Canadian Fisheries Act								
16	2.2 Province of Ontario										
17	12	2.1.12	Occupational Health and Safety Act	see 2.1.10							
18	13	2.1.13	Ontario Building Code		2006	MMAH	Link	2000	150.00		
19	14	2.1.14	Ontario Electrical Safety Code		2002	ESA	Link		99.00		
20	15	2.1.15	Ontario Water Resources Act								
21	16	2.1.16	Professional Engineers Act								
22	17	2.1.17	Architects Act								
23	18	2.1.18	Trades Qualification and Apprenticeship Act								
24	19	2.1.19	Environmental Protection Act								
25	20	2.1.20	Environmental Assessment Act								
26	21	2.1.21	Regulations for Industrial Establishments								
27	22	2.1.22	Regulations for Construction Projects								
28	23	2.1.23	Ontario Water Resources Act	redundant to 2.1.15							
29	24	2.1.24	Ontario Traffic Manual			Ministry of Transportation					
30	25	2.1.25	Supplier Act								
31	26	2.1.26	Transport of Dangerous Goods Act								
32	27	2.1.27	Gasoline Handling Act								
33	28	2.1.28	Energy Act								
34	2.3 City of Toronto										
35	29	2.3.1	Municipal Code								
36											
37	Legend										
38											
39	CSA	Canadian Standard Association									
40	ESA	Electrical Safety Authority									
41	MMAH	Ministry of Municipal Affairs and Housing									
42	NRCC	National Research Council Canada									
43	RAC	Railway Association of Canada									
44									Total (CAD):	\$829.00	

Technical Standards

Technical Standards take on the aspect of project requirements if:

- They are called out in a contract

“All systems work shall be done in accordance with IEEE 1220”

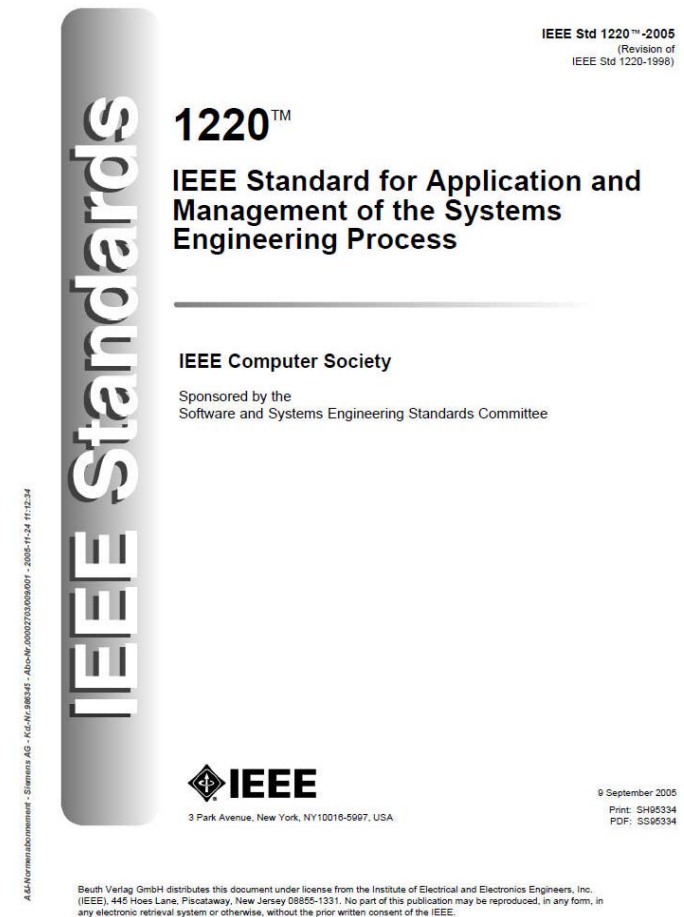
- And they apply:

They may be project execution requirements

“Code reviews shall be conducted per IEEE Std 1028-1997”

Or they may impact deliverables

“Delivered circuit breakers shall conform to IEEE C37.13.1-2006”



Contract Option

- ❑ A contract option is a clause in a contract defining one or more requirements
- ❑ If exercised by the client before the expiration date it becomes a legal and binding part of the contract
- ❑ If allowed to expire, any requirements associated with the option are null and void.

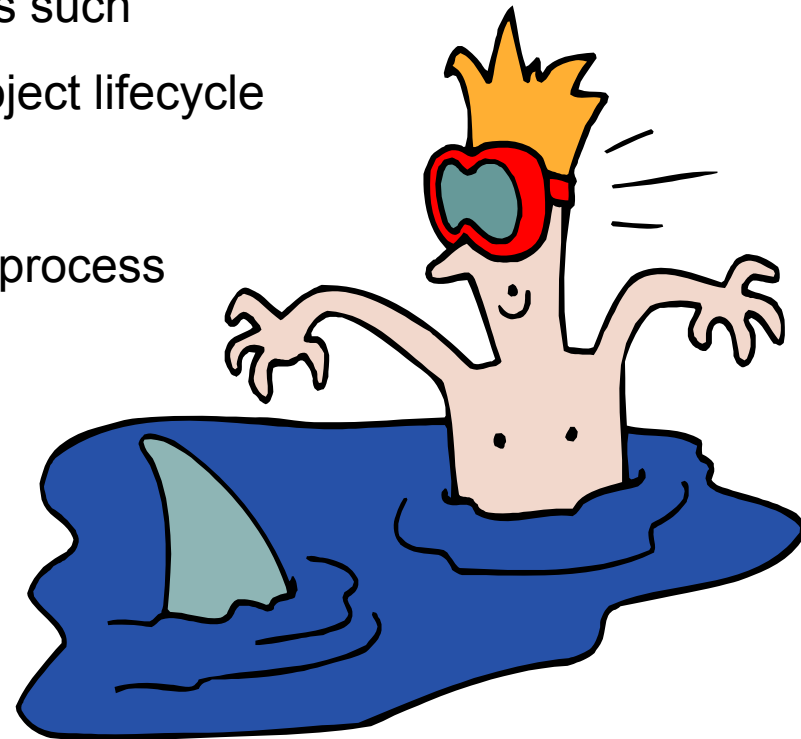
Maybe I want an automatic...
Maybe I want power
windows... Maybe I want
heated seats... Maybe I want it
to be black... Maybe I...



Contract Option - Concerns

Contract options can be dangerous to the supplier if not properly managed:

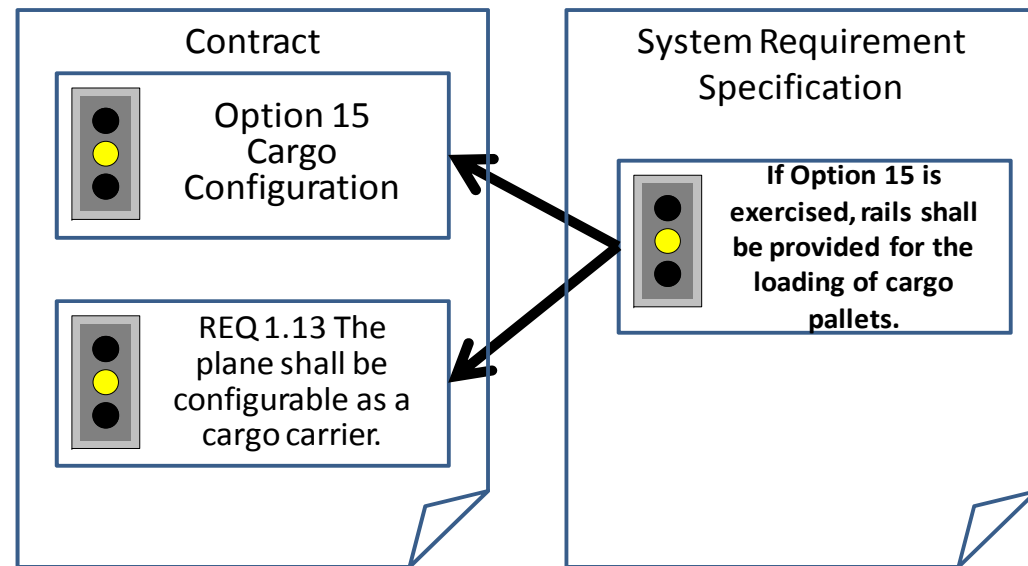
- ✓ Making sure that options are clearly marked as such
- ✓ Propagating exercised options through the project lifecycle
- ✓ Ensuring that the tool chain supports options
- ✓ Incorporating options into the change request process



Propagating Contract Options

Contract options differ from regular requirements:

- ✓ They are in the contract but may not be exercised
- ✓ If exercised by the buyer before the expiration date they become legally binding.
- ✓ They may not be exercised after the expiration date.



Penalty Clause

“A Provision in a contract that imposes penalty on the defaulting contracting party for a specified default.”

It can be:

- A one time payment
- Ongoing payments based on some criteria
- Loss of access to the client for future work
- Cancellation



Penalty Clause - Example

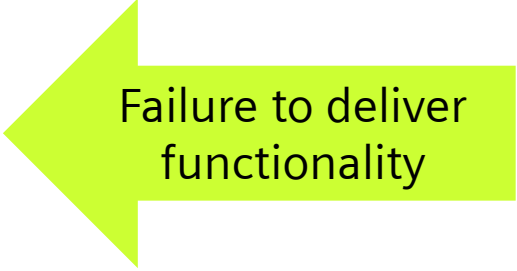
Sample*:

(i) Delay in supplying the items within the stipulated period of one week
The office reserves the right to deduct 2% of the cost of supply order for the item for each day after the stipulated period.

Late Delivery

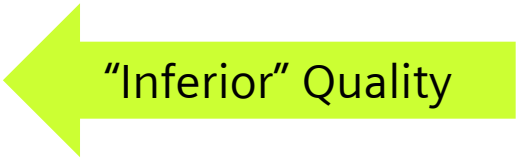
(ii) Failure to supply the items or failure to supply the items that conform to the Quotation.

The office reserves the right to remove the vendor from empanelment and or forfeit the Bank Guarantee/Deposit at Call submitted by the vendor or/and forfeit any amount (in part or full) due to the vendor and issue fresh supply order to any other vendor in the panel.

Failure to deliver functionality

(iii) Supplies that are inferior in quality.

The office reserves the right to cancel the entire supply order or part of the supply order, as it may think fit and also invoke clause (i) and/or (ii) above.

"Inferior" Quality

*Taken from an RFP by a government agency posted on the web

Incentive Payment

Incentive Payments are payments fully defined in a contract that are made upon meeting certain milestones or criteria, e.g. early delivery.

“If the work is completed prior to the time for completion specified in this contract, the Owner shall make an incentive payment to the Contractor. The amount of the payment shall be ascertained according to the instructions on the attachment entitled Incentive Payment Computation which is made a part hereof.”

Issues With Incentive Payments:

- ✓ **The incentive might not be passed from project management to requirements analysis**
- ✓ **It may remain vague.**

For example, there may be an incentive payment for the installation of a communications system, whereas there may not be an incentive payment for the installation of heating and air conditioning systems in the same facility. The requirements for the communication system must then be prioritized at a higher level than heating and air conditioning. When requirement specifications or work breakdown structures and schedules are generated, the communication system would be clearly marked as having a high priority.

Requirements Analysis – Identification of Risk

*“The chance of injury, damage, or loss, and liability for such if it occurs”**

Technical Risk

- Cost to build solution (e.g. new features)
- Schedule & Resources
- Evaluation of non-functional requirements
 - May require modeling, simulation or evaluation of third party products

Financial Risk

- Terms and conditions
- Penalties
- Adverse publicity

Legal & Corruption Risk

- Company or division specific limits of authority



*B. Garner, *Black's Law Dictionary*, West Publishing Company, St. Paul, Mn. 2009, page 1442.

Risk Avoidance Techniques during Analysis

Risk Avoidance Technique	Original Requirement	Potential Risk	Rewritten Requirement
Assumption	"Off-the-shelf Fiber optic backbone shall be used."	We make the assumption that the risk associated with the use of Fiber optic backbone is minimal.	Requirement is left unmodified.
Control	"The milestone payment shall be made upon acceptance of the user manual by the client."	The supplier has no control of the acceptance of user manuals; it is based on subjective criteria.	"The milestone payment shall be made upon delivery of the first draft of the user manuals to the client."
Transfer	"While shipping shall be arranged by the client, the supplier shall be liable for any damages incurred in shipping."	The supplier has no control but bears the liability should there be damage; transfer responsibility to the client	"Shipping shall be arranged and managed by the supplier."
Avoidance	"The control system displays shall show all plant maps in three dimensions using 3D monitors and software."	The technology is a risk. It may not be ready for commercial use when control system manufacturing or installation is scheduled to take place.	"The control system displays shall show all plant maps in two dimensions using 2D monitors and software. Post installation, the client may request a second contract be negotiated for the conversion from 2D to 3D once the technology becomes available."



[Brian replace with table]

Request for Clarification (RFC)

- Clarification to quantify and resolve ambiguities before they become legal or financial problems
- Improves client/contractor relationship
- Requires management review before submission to client

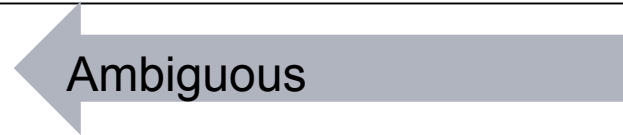
Beware:

- Incorrect phrasing of the RFC may be insulting to the client or client contractor, e.g. “Why do you want A instead of B when B is better?”



Request for Clarification - Example

RFP: “The network is easily expanded”



Request for Clarification
Original Statement: “The network is easily expanded”
Proposal: “We propose the use of a standard broadband network with a fibre optic backbone to meet the definition of easily expanded.”
Rationale: “A standard broadband network meets the clients needs, is cost effective, and uses commodity components that are mature and reliable.”

This is:

- ✓ Testable
- ✓ Removes ambiguity
- ✓ In contractors favor (he was going to do it anyway)
- ✓ Does not hurt client relationship

Compliance Matrix

A **Compliance Matrix** is the matrix produced as a result of performing formal analysis on the requirements in an RFP, and later a contract, that describes, for each requirement, the supplier's ability to meet the requirement, any risk, and other factors such as cost

□ Requirement Satisfaction

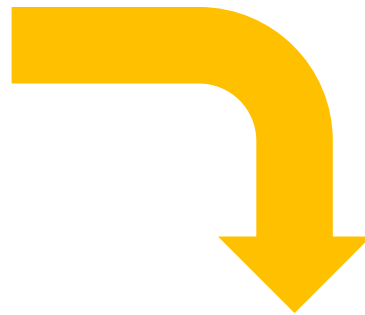
- Meets Requirement Unconditionally: the bidder unconditionally meets a requirement
- Meets Requirement Conditionally: the bidder cannot meet the requirement as stated but proposes an alternate solution
- Exception: the bidder can or will not meet the requirement

□ Cost drivers

- Requirements which dramatically increase the cost of the bid. These are normally split out and made options in the proposal to make the bid more attractive. Alternative, less costly solutions might be proposed.

Note: if the bidder proposes an alternative during the Q&A pre-bid, then all the other bidders see the question and answer.

Compliance Matrix - Example



Extract Requirements



RFP Id	Status	Rationale	Risk	Extra Cost
2.2.4	Clarify	vague	high	tbd
2.2.5	Comply	Product supports feature	none	none

Compliance Matrix

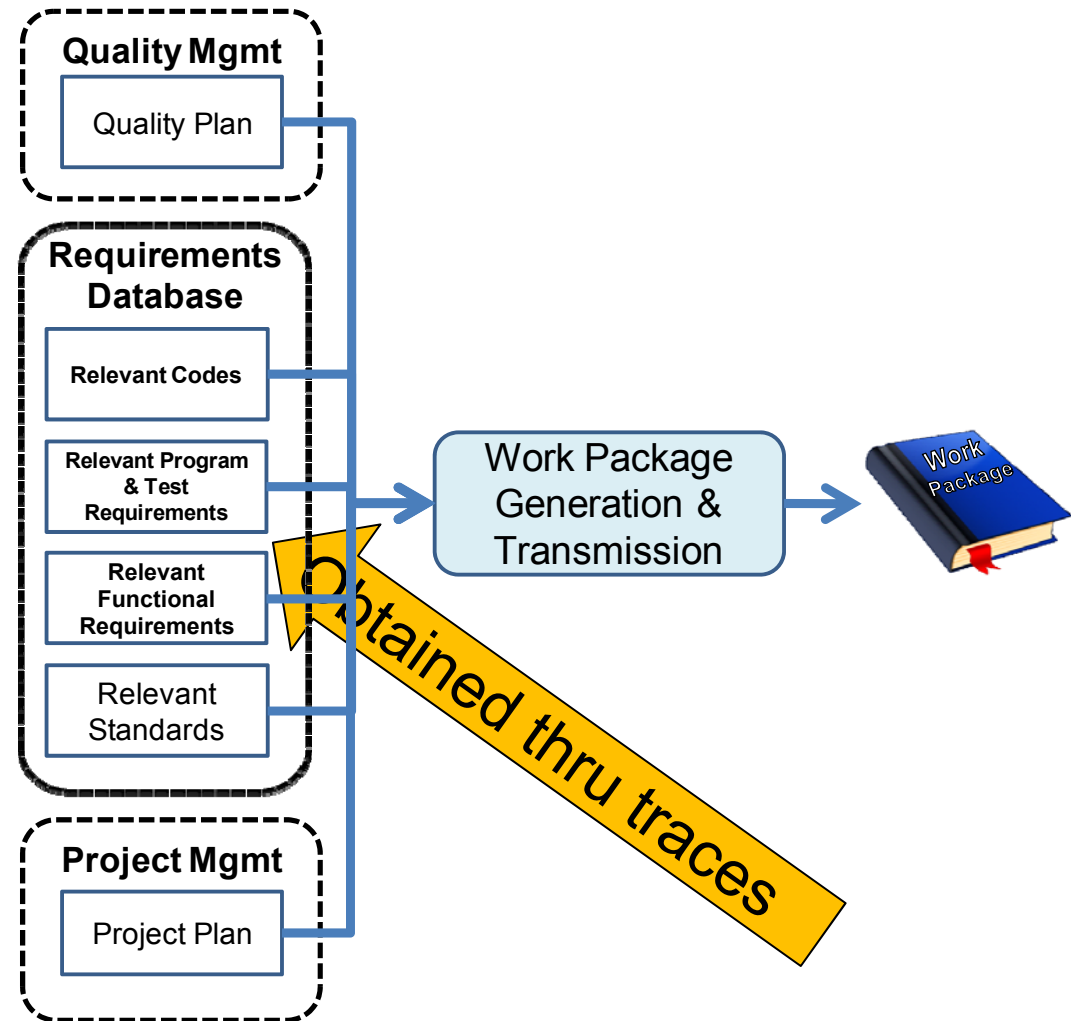
Creation and Generation of Work Packages

Work packages must be generated and transmitted to prime and subcontractor responsible management including:

- Relevant Cross-Cutting Requirements
- Relevant Project Execution Requirements
- Relevant Contract Requirements
- System, subsystem, component and assembly requirements derived from the contract requirements
- References to applicable regulatory codes
- Schedules and deadlines

Creation and Generation of Work Packages

"A CWP* is a **construction deliverable** that defines a specific scope of work and should include a budget and schedule that can be compared with actual performance. The boundaries of the CWPs, the complete list and the priorities must be developed by Construction during the front end of the Engineering phase, in conjunction with the path of Construction so the sequence of the Engineering and Procurement deliverables can support the Construction requirements. The CWPs are assembled by Construction before the work gets to the field. The CWP will always include a description of the work, list of drawings and materials/equipment to be installed, reference documents (such as P&ID's, specifications, etc.) and should include estimated manpower, scaffolding and construction equipment requirements, safety, quality, subcontract administration, permitting and regulatory requirements. "**



* Construction Work Package

**Construction Owners Association of Alberta, November 2007

Conclusions

- Requirements engineering processes for contract- based systems are considerably more complex than those used for product development.
- Penalty and option clauses may not be treated as requirements and may be handled in a disjoint manner.
- Very little work has been done to study the transfer of information from prime to subcontractor.
- *We believe that the application of RE “Best Practices” to contract- based projects has the potential for improving productivity and contributing to project success, and further research is needed to define those best practices.*

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Questions?

