Large Scale Software System Development

The role of *creating systems engineering* in the Interfront iCBS development program

(11 April 2013)

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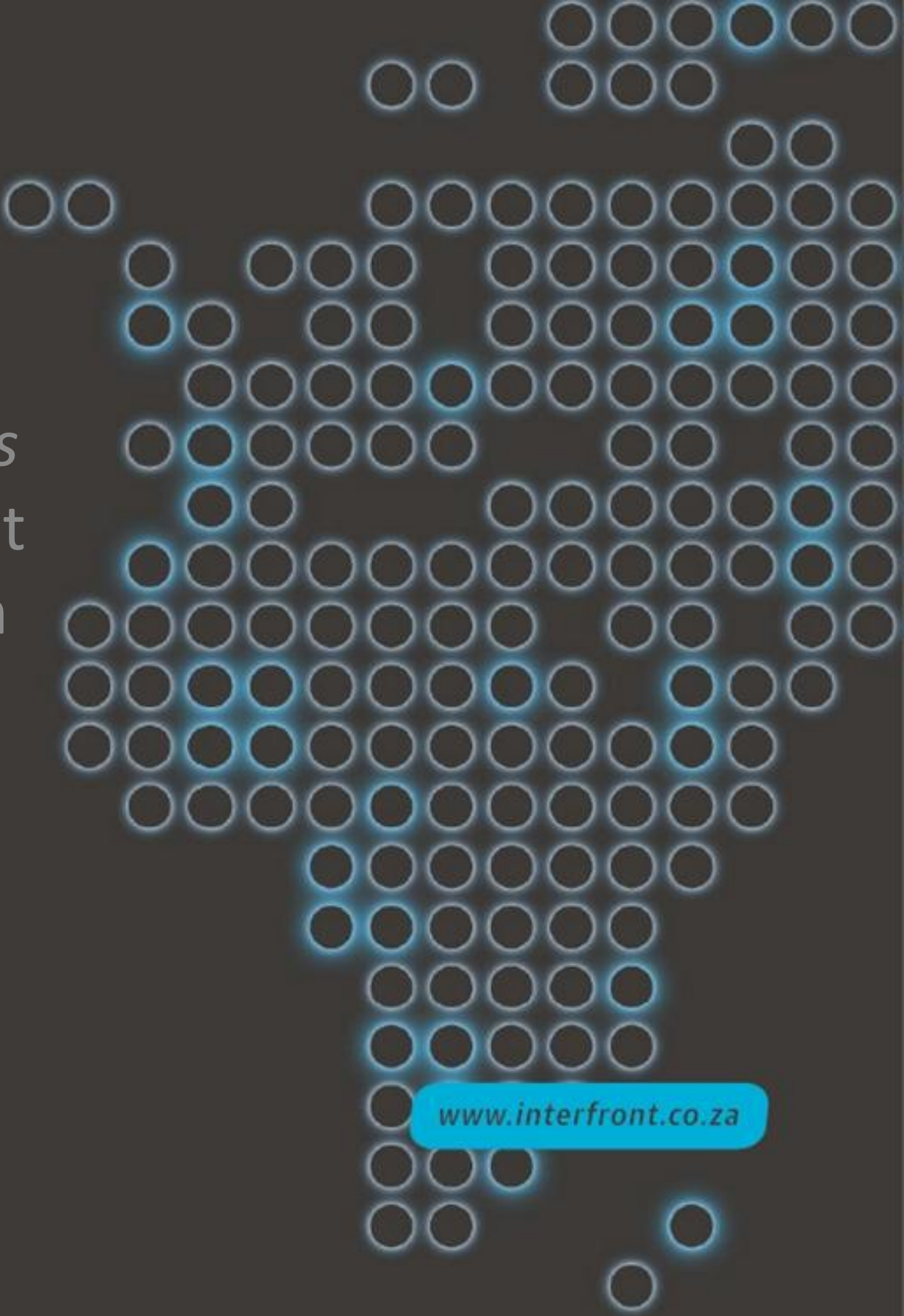


Overview of Case Study presentation

1. Introductions
2. Program size and context complexity
3. System of systems challenges encountered
4. Program achievements
5. Systems engineering approach
6. Engineering the creating system
    a. Organisational system
    b. Technical enabling system
7. Some notes on the application of agile development methodologies

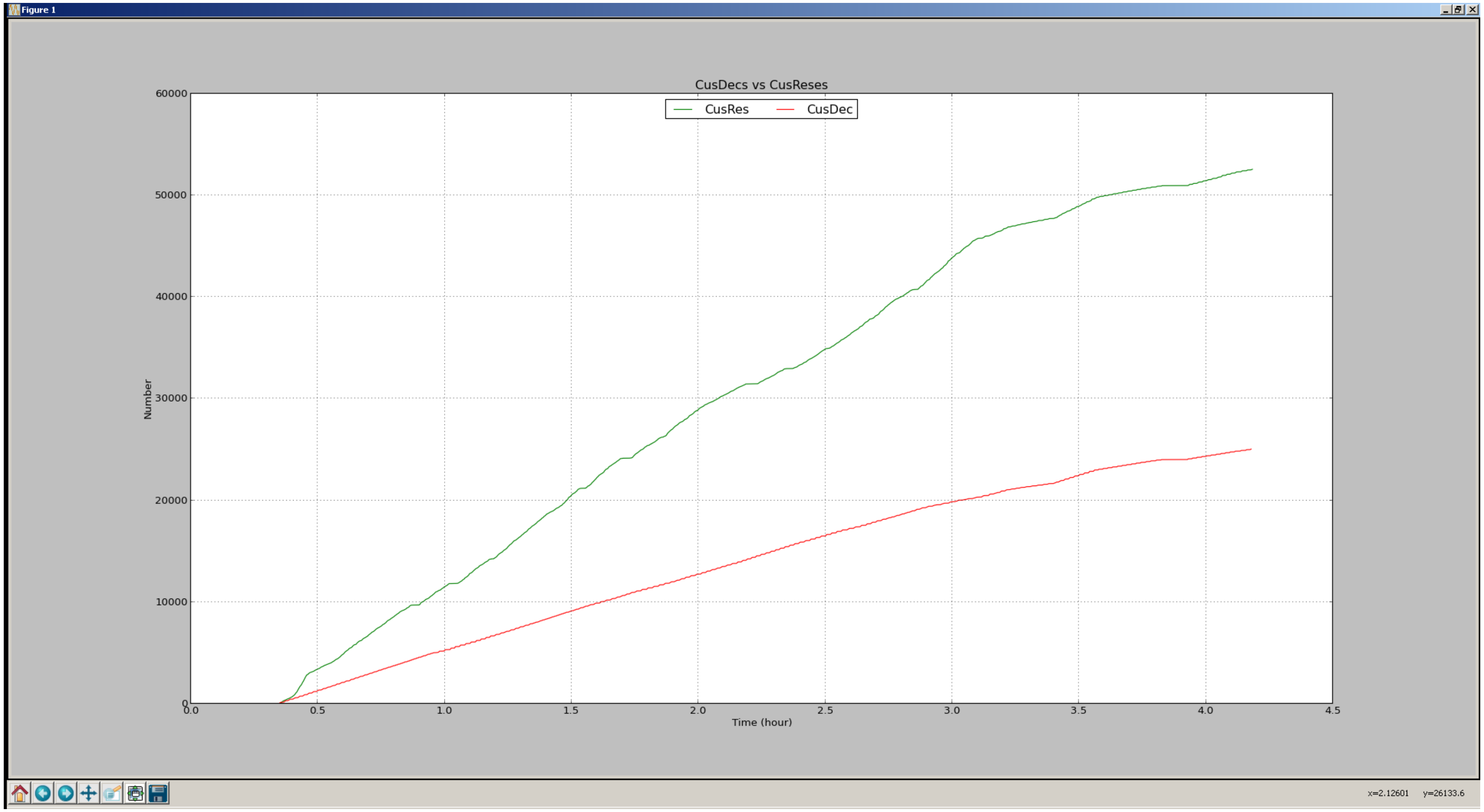
Introduction

- Interfront
- SARS Customs Modernisation Program
- My involvement

Product size and complexity

- **Functional scope:** Core declaration processing sub-system – 27 Use Cases and 300 requirements
- **Business Rules:**
  - 1,321 Configurable rules
  - 158 Complex rules
  - 146,340 Default conditionalities
- **Sub-systems:** 6
- **Managed xsd interfaces:** 29
- **Queues:** 71
- **Code base:** 2 EAR's, 32 WAR's, 325 JAR's
- **Performance/Load requirements:**
  - end-to-end transaction: Average 50 sec (1-10,000 line declarations)
  - current production load: 20,000/day. Must scale to 60,000/day.
  - Parallel run: 25,000/4 hrs = 6250/hr = 104/minute
- **Availability requirements:** 24/7 (Upgrades midnight)
- **Reliability/Integrity requirements:** 100% transactions accounted for. Accuracy of duties/taxes (scents-level)

System performance



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Context complexity

- **Context complexity**
  - Team size: 63
  - External interfacing systems: 10
  - User/Operator interfaces: 4 (different operational functional/support departments)
  - Contracting parties: 6
  - Distributed program team
  - Dynamic, fast pace project and industry in government organisation (bureaucratic establishment)
- **High degree of uncertainty (context complexity)**
  - Full scope of system unclear and continuously changing
  - No specification or complete description of existing system to be replaced
  - Transition strategy being developed as the system matures
  - Daily detail requirements changes (small to large impact) in a response to daily legacy system parallel testing

The SARS context...

ASSISTANT TO THE AIDE OF THE DEPUTY
VICE CHAIRMAN OF THE COMMITTEE
TO REDUCE PENTAGON BUREAUCRACY
Bennett THE CHRISTIAN SCIENCE MONITOR

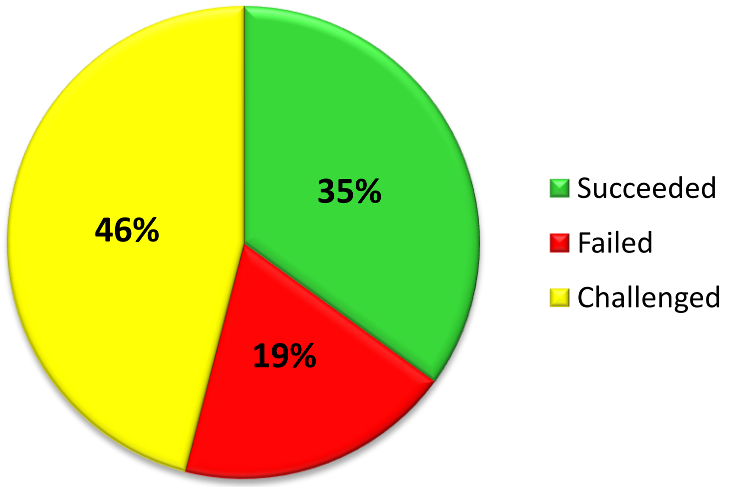
Typical system of systems (SoS) Challenges

1. **System elements operate independently**
2. **System elements** have **different life cycles**
3. The **initial requirements** are **likely to be ambiguous**: Requirements for an SoS mature as the system elements mature
4. **Complexity** is a major issue: Added system elements result in non-linear interaction growth
5. **Management can overshadow engineering**: coordination of requirements, budget constraints, schedules, interfaces, and technology complicates development
6. **Fuzzy boundaries cause confusion**: No one controls the definition of the external interfaces unless someone defines and controls the system boundaries
7. **SoS is never finished**

Software Development still seriously challenged: Standish CHAOS report

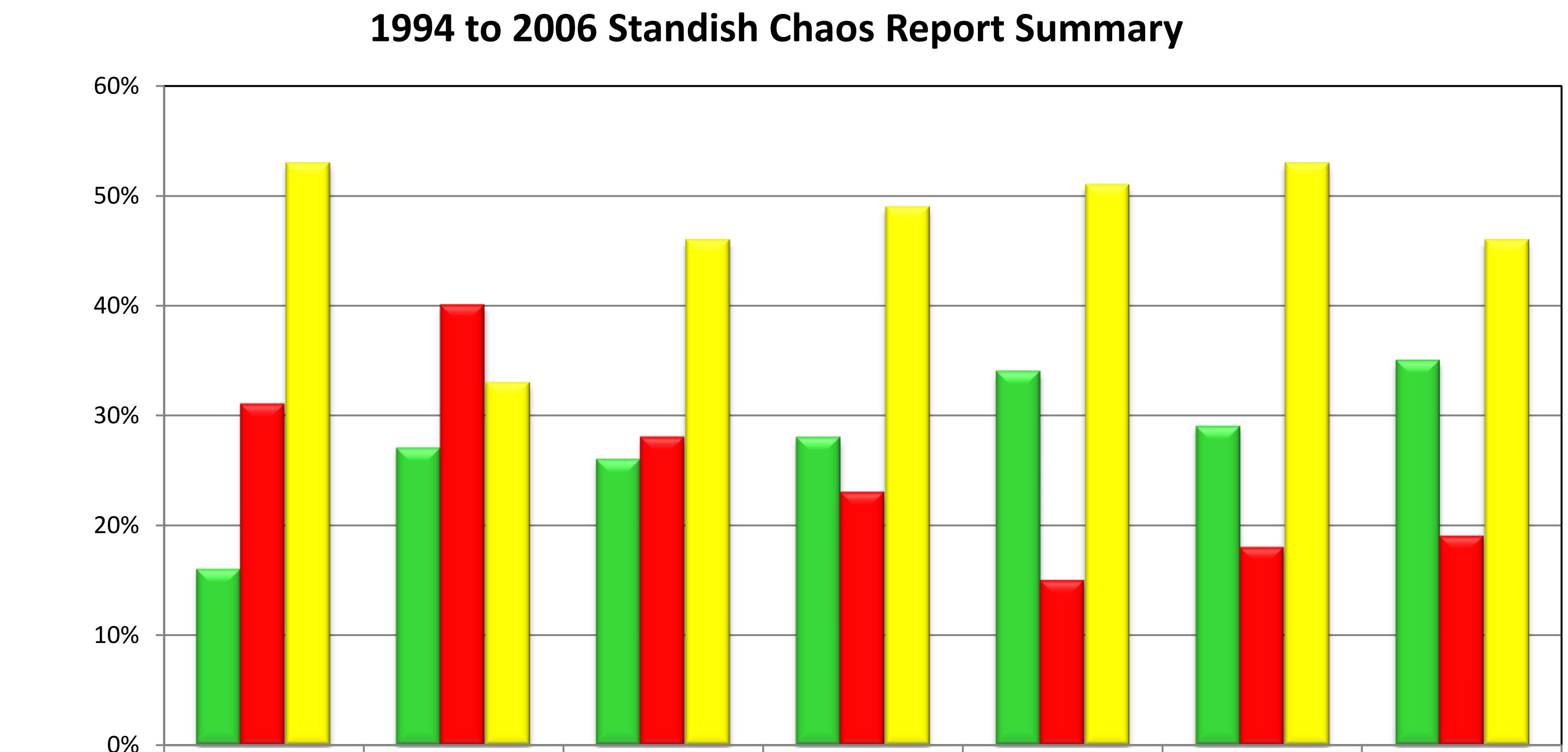
- 50,000+ Software Projects
- Around the world
- Since 1994
- 2009 results – even worse:
  - 32% succeed
  - 44% challenged
  - 24% failed

2006 Chaos Report Summary



Source: Standish Group

Standish CHAOS report summary



	1994	1996	1998	2000	2002	2004	2006
🟩 Succeeded	16%	27%	26%	28%	34%	29%	35%
🟥 Failed	31%	40%	28%	23%	15%	18%	19%
🟨 Challenged	53%	33%	46%	49%	51%	53%	46%

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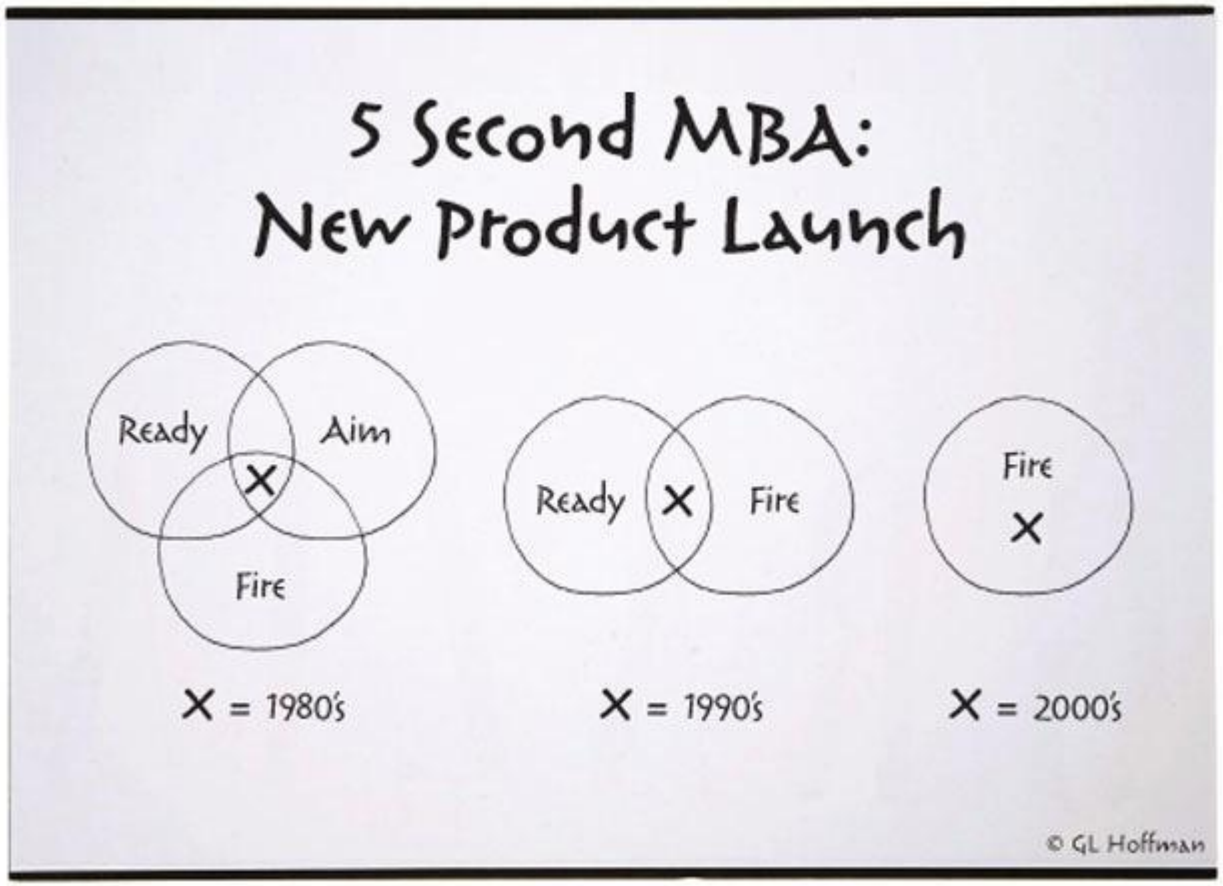
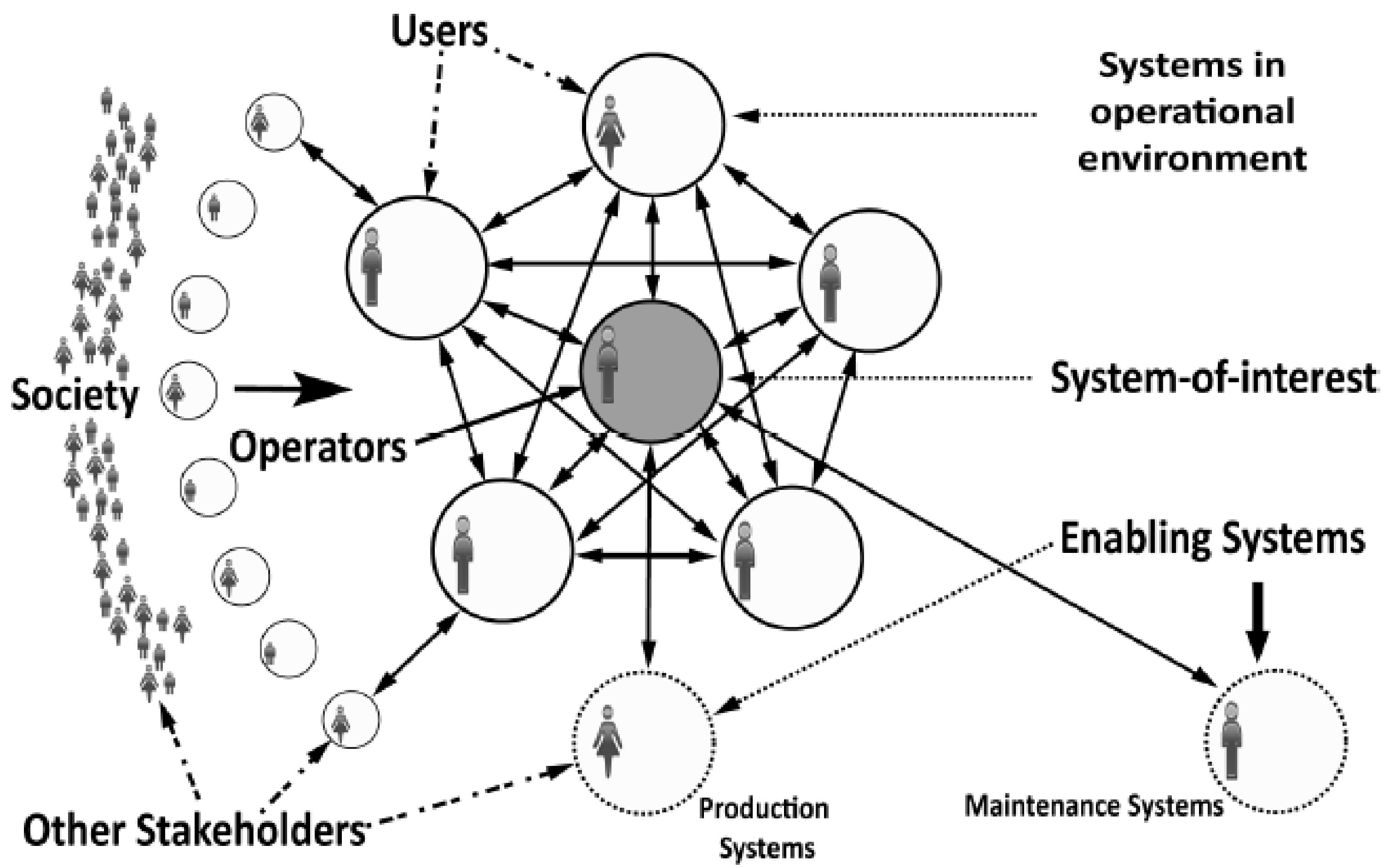
Program Achievements

- **Daily full system releases**: Full build, full regression testing, integration, transition into production environment, data loading, deploy, stabilise, full parallel testing run
- **Running whole country's declarations through INTF system and comparing to legacy daily – automated** (execution, results and comparison analysis). Currently less than 5% overall differences in INTF and legacy results.
- **Daily production delta data take-on** (of all sub-systems)
- **Coverage of all system activity**, catching all exceptions and faults, with ability to manage and resolve issues with needed security clearance levels (System Management Console)
- **Track any message end-to-end** from any of the systems in the greater SARS system. "Every transaction is precious"

Learning fast...



Systems Engineering: System of systems in context



Source: INCOSE Systems Engineering Handbook, 2010

Key SE-related concepts

- Change management
- Configuration Management
- Non-functionals (“ilities” / RAMS)
- Error/Failure Handling (FMEA/FMECA)
- Created vs creating system (Enabling Systems Engineering)
- Management of internal and external dependencies
- Information Management
- Quality Management
- Decision Management
- Risk Management

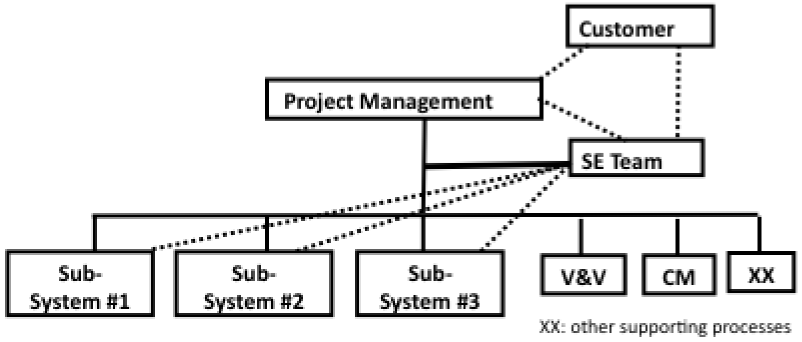
Reference: SE Body of Knowledge (http://www.sebokwiki.org)

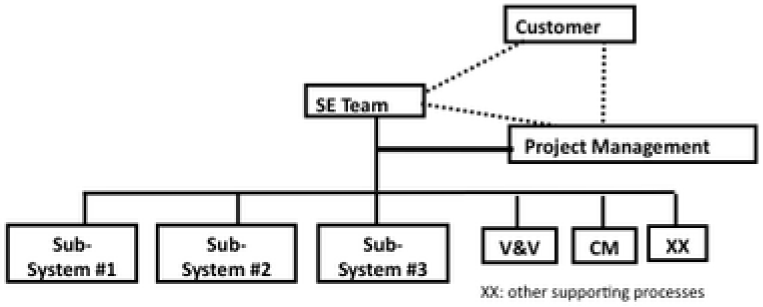
Creating/Enabling Systems Engineering

- Estimated 30-50% of program effort went into development and maintenance of the ‘creating system’ (i.e. 20-30 out of every 60 man hours)
- Includes:
  - Enterprise systems engineering (incl. Process)
  - Tooling and supporting system engineering

Structuring teams and organisations to develop SoS's

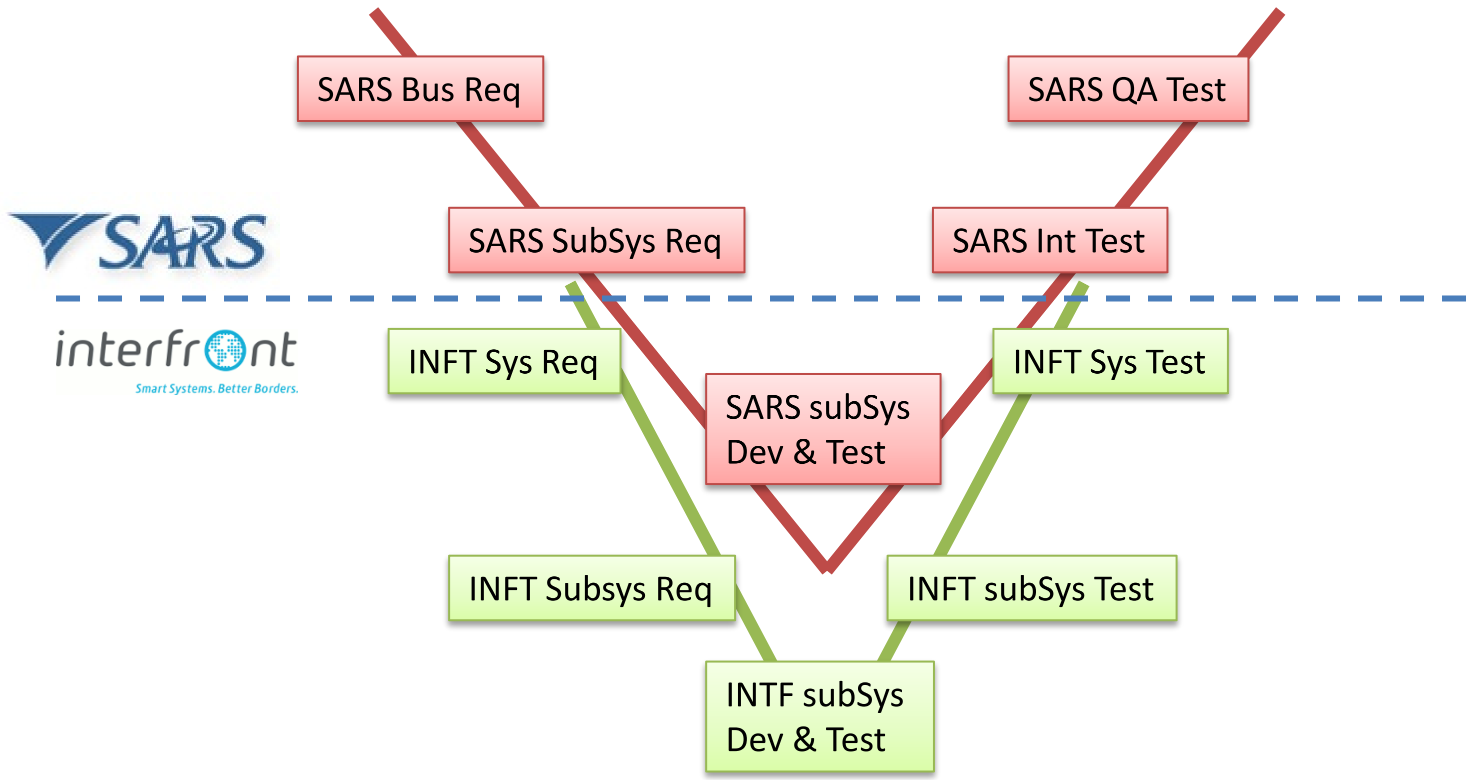
- **Conway's law: "**...organizations which design systems ... are constrained to produce designs which are copies of the communication structures of these organizations"
- **Balance in system & organisational hierarchies**: 7 ± 2 rule (manage organisational and communication complexity)





Source: SE Body of Knowledge (http://www.sebokwiki.org)

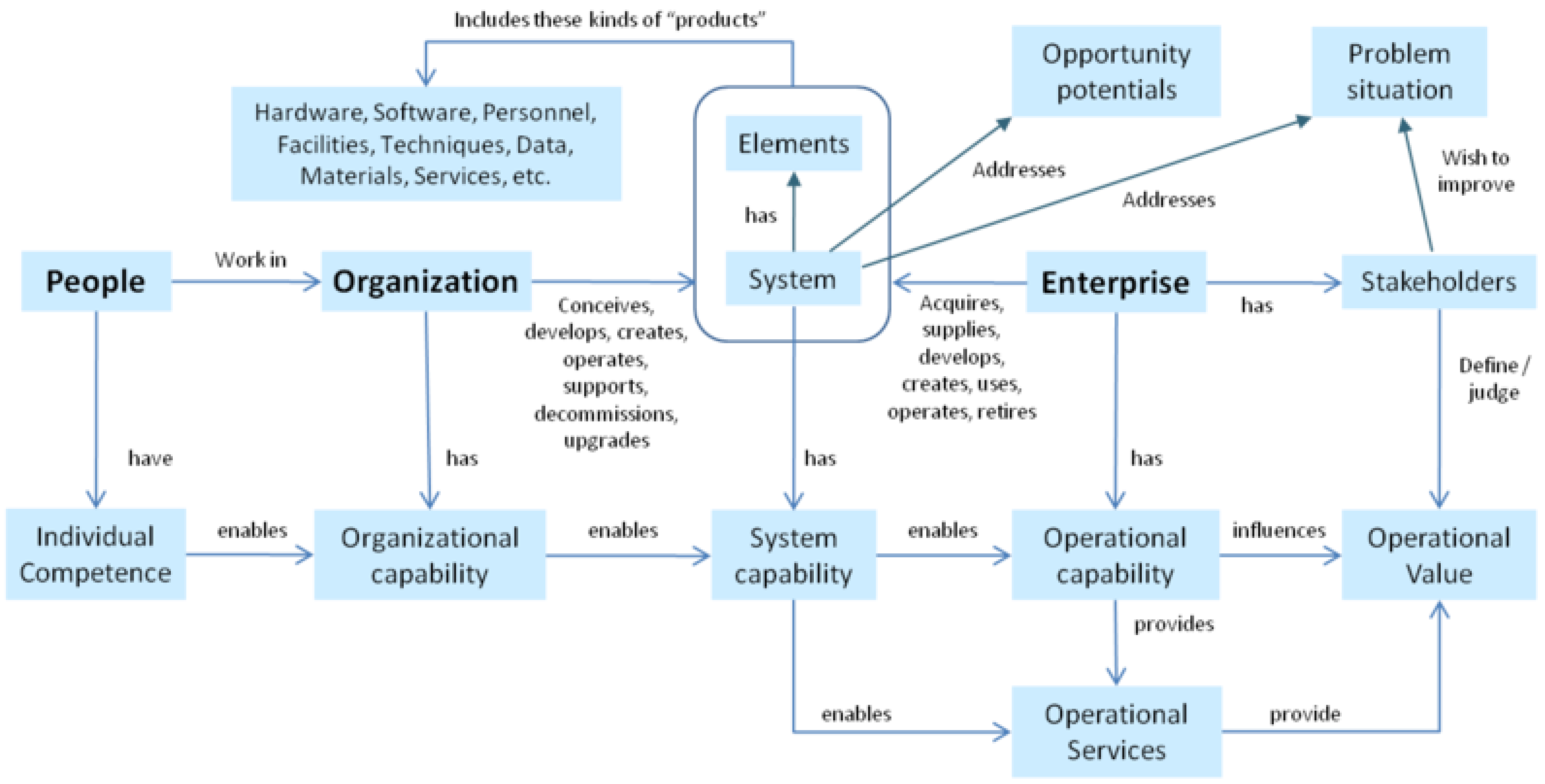
SARS & Interfront SDLC's overlay



Relevant ‘Creating system’ concepts

- **Enterprise Systems Engineering** (ESE): The application of systems engineering principles, concepts, and methods to the planning, design, improvement, and operation of an enterprise (SE Body of Knowledge http://www.sebokwiki.org)
- **Self-organising teams:** (i.e., not organised by mandate) in that the sentient beings in the enterprise will **find for themselves some way in which they can interact to produce greater results than can be done by the individuals alone**. Self-organizing enterprises are often more **flexible** and **agile** than if they were organized from above (Dyer and Ericksen 2009; Stacey 2006)
- **DevOps:** DevOps is frequently described as a **more collaborative and productive relationship between development teams and operations teams**. This improved relationship and collaboration **increases efficiency** and **reduces the production risk associated with frequent changes**. (Wikipedia)
- **Release Management:** The process of managing software releases from development stage to software release. (Wikipedia)
- **Continuous Integration:** the practice, in software engineering, of merging all developer workspaces with a shared mainline several times a day

Capabilities in the Enterprise



Individual Competence Leads to Organizational, System & Operational Capability

Key ‘creating system’ elements (Process & Organisation)

- **Team structuring**
  - **Systems engineering capability** in Interfront and SARS
  - **Independent data team** controlling interface specifications and data baselines
  - Instilling self-contained functions for **‘new’ software development disciplines**:
    - Release Management
    - DevOps
  - **Self-organising teams**
  - **Interdependence** between teams (reflected in KPIs)
- **Requirements and specification practices**
  - Blue Print and specification base lining (Enterprise Architect)
  - Formal Change management (ECPs, issue logs etc)
  - Documentation management (drafts, releases, distribution control)
- **Interfront release approach**
  - Incremental system releases
  - Release planning and documentation (continuous)
  - Disciplined issue tracking and reporting
  - Internal Release Management incl. full release content audits
  - Baseline control register (system of systems level)

Key ‘creating system’ elements (Process & Organisation) cont....

- **Continuous integration**
- **Systems Engineering & Design Authority** (SE&DA) (Cross-discipline, cross-team design function facilitated by SE)
- **Test and Qualification approach**
  - Verification and coverage measure **against specification** (RVTM’s)
  - **Levels of qualification** testing with **quality gates**
  - **Regression testing documentation** and **configuration control** for repeatable execution, and change control of test case procedures
  - **Qualification environments** management
- **Establishment of rhythms**
  - **Daily rhythms** enabled through self organising teams: Program level, team level, client interactions

    Daily dev cycle: reporting, analysis, planning, implementation, build, test and release
  - **Weekly rhythms**: Program steerco, Project reporting, SEDA sessions, ECPs scheduling and building

Business Agility – Enterprise Architecture

One **type of enterprise architecture** that **supports agility** is a **non-hierarchical organization without a single point of control**.

Individuals function **autonomously**, **constantly interacting** with each other to define the vision and aims, **maintain a common understanding** of requirements and monitor the work that needs to be done.

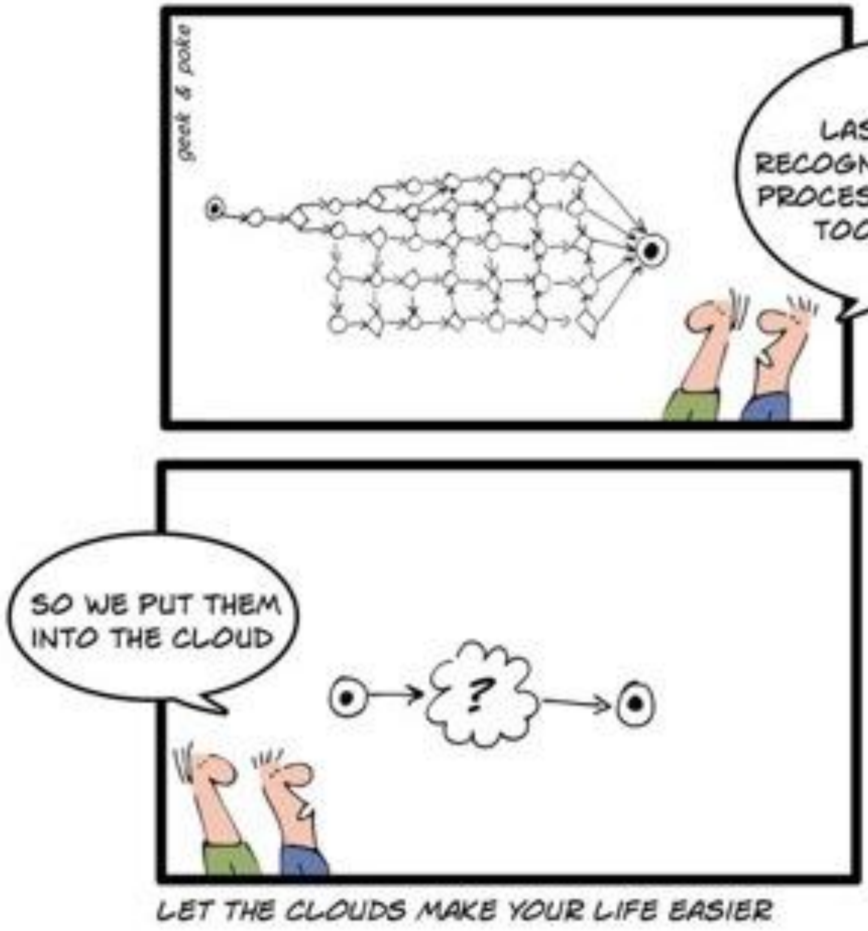
Roles and responsibilities are **not predetermined** but rather **emerge from individuals' self-organizing activities** and are constantly in flux.

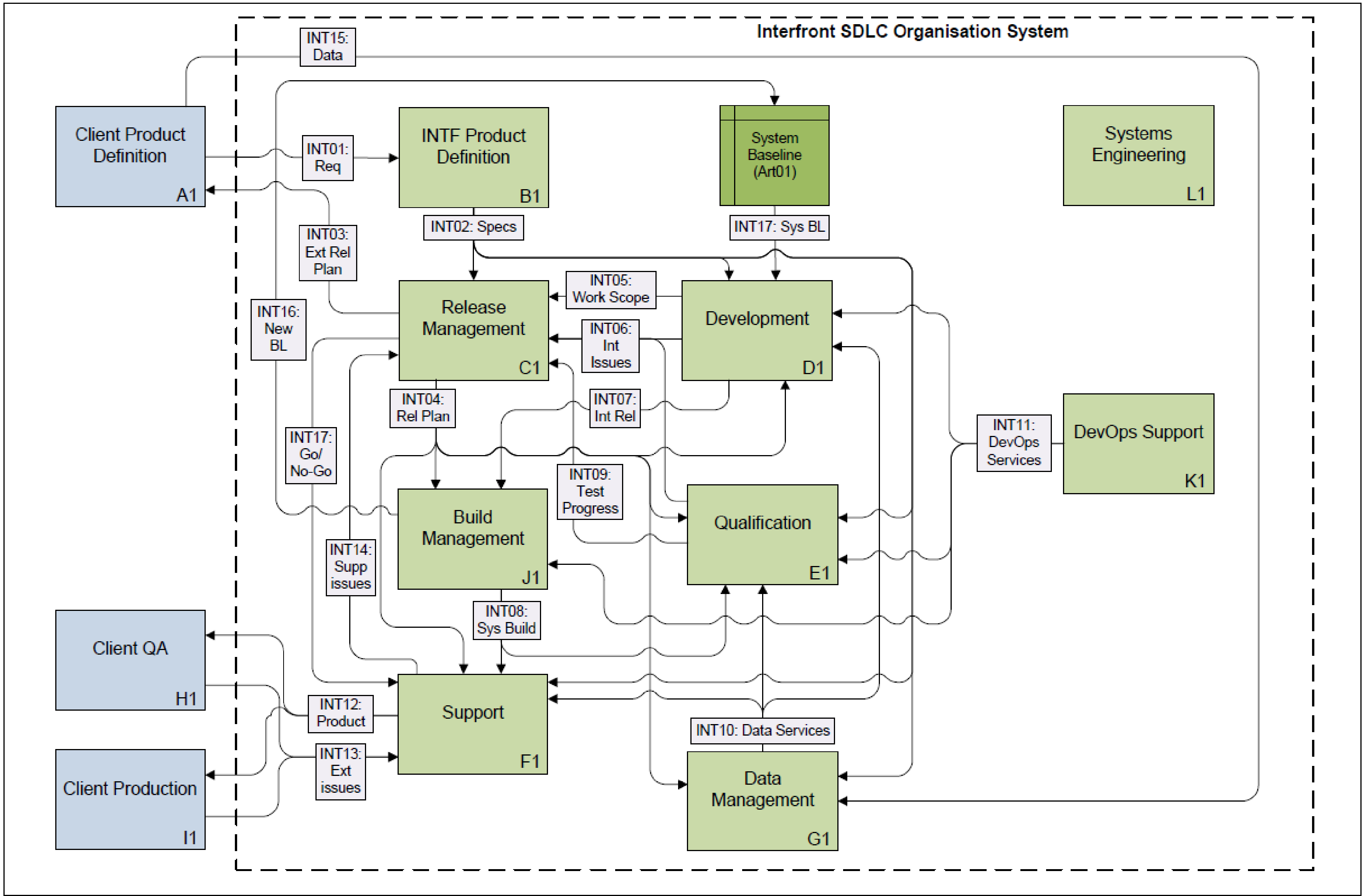
Key decisions are made **collaboratively**, **on the spot**, and **on the fly**.

Because of this, **knowledge, power, and intelligence are spread through the enterprise**, making it uniquely capable of **quickly recovering** and adapting to the **loss of any key enterprise component**.

Source: (http://en.wikipedia.org/wiki/Business_agility)

Processes...


geek & poke
LAST YEAR WE RECOGNIZED THAT OUR PROCESSES WERE FAR TOO COMPLEX
SO WE PUT THEM INTO THE CLOUD
?
LET THE CLOUDS MAKE YOUR LIFE EASIER



NODE: A0	TITLE: Interfront SDLC Organisation System Block Diagram	NO.: Version 2.0

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ECP Process

- ECP: Engineering Change Proposal
- Changes in requirements are managed by ECP’s
- It provides a structured and controlled approach to product changes and project planning (incl. costing)
- ECP’s includes:
  - Detail descriptions/specification of the required change
  - An impact assessment of the change i.t.o. :
    - Work required to implement
    - Cost to implement
    - Timescale impact on other items already in development
- ECP’s are formally approved by the client before development is triggered, which serves as the delivery contract
- Approved ECP’s are added to the product’s functional baseline

Continuous Integration

***Continuous Integration (CI)** is a **software development practice** where members of a team **integrate their work frequently**, usually each person integrates **at least daily** – leading to multiple integrations per day. Each integration is **verified by an automated build** (**including test**) to **detect integration errors as quickly as possible**. Many teams find that this approach leads to significantly reduced integration problems and allows a team to **develop cohesive software more rapidly**.*

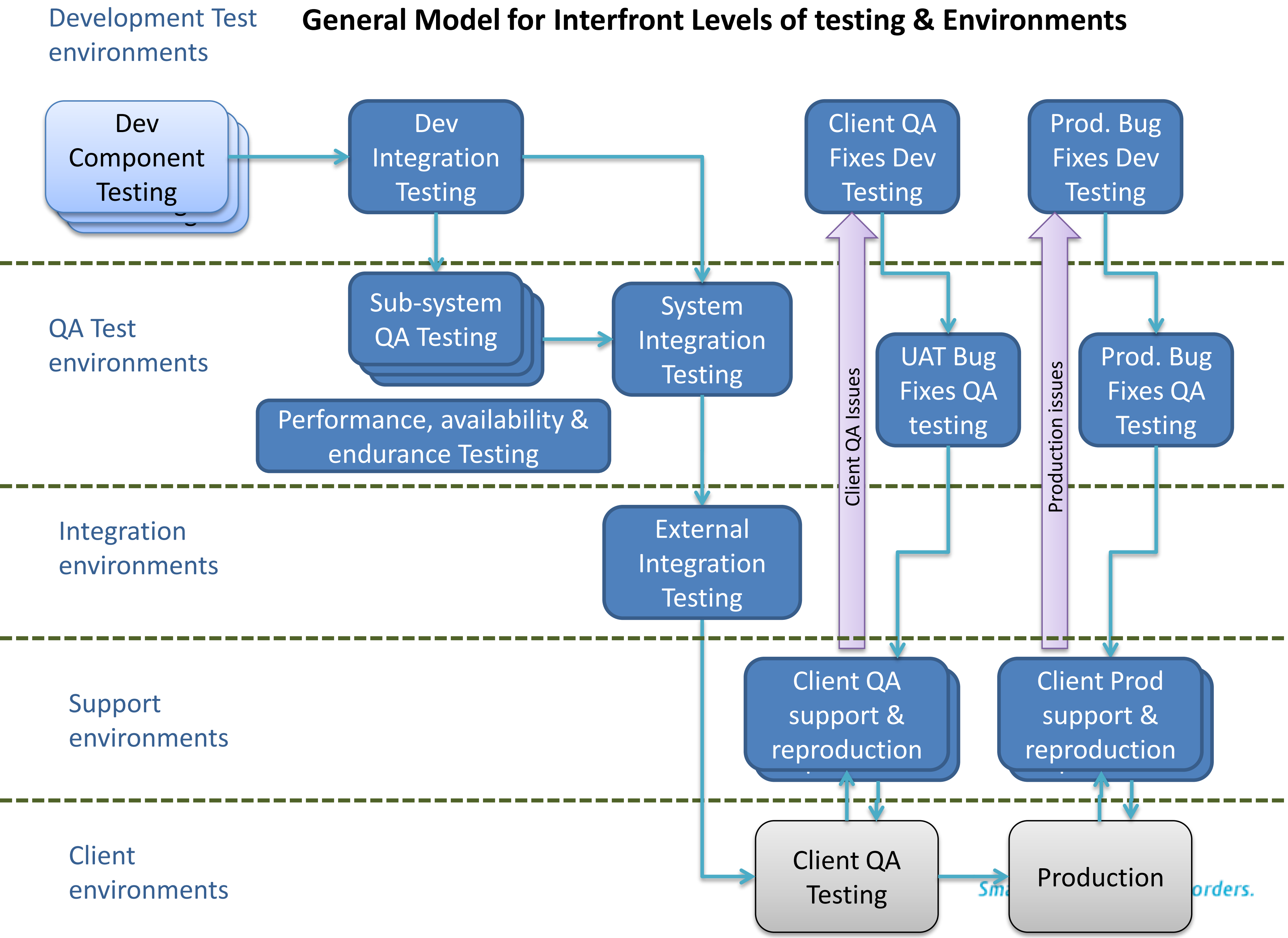
(Martin Fowler)

- Early identification of faulty software
- Automated
- 100% pass rate of all tests required
- Immediate roll-back on failure (strict baseline and stability control)
- Down-stream qualification efforts maximised for system level functional testing

System Engineering & Design Authority (SE&DA)

- Multi-disciplinary
- Typical topics:
  - Archiving strategy and implications
  - System Upgrade and data migration strategy
  - Logging approach and levels
  - Error handling across the system
  - Transaction auditing across the system
  - Queue monitoring and reporting for support
  - Operationalisation and external system Integration

General Model for Interfront Levels of testing & Environments


Development Test environments
Dev Component Testing
Dev Integration Testing
Client QA Fixes Dev Testing
Prod. Bug Fixes Dev Testing
QA Test environments
Sub-system QA Testing
System Integration Testing
UAT Bug Fixes QA testing
Prod. Bug Fixes QA Testing
Performance, availability & endurance Testing
Client QA Issues
Production issues
Integration environments
External Integration Testing
Support environments
Client QA support & reproduction
Client Prod support & reproduction
Client environments
Client QA Testing
Production

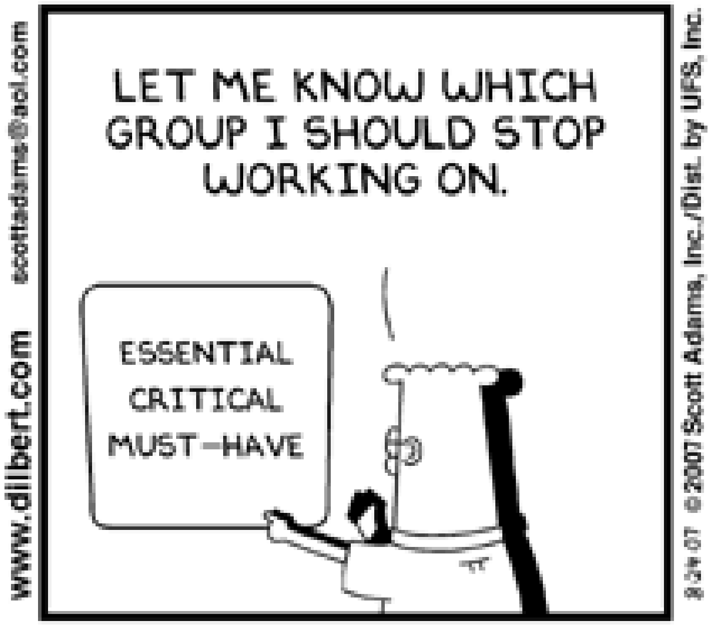
Key ‘creating system’ elements (Technical and Tooling)

- **Code generation:** Spec change results in new interface model which gets directly translated into code (reduced time from 6 wks average to 10mins)
- **Integrated System Life Cycle Management infrastructure (ALM)**:
  - Bugzilla (end-to-end item management, target milestone deliveries, item statuses)
  - SVN
  - Continuous Integration Infrastructure (Jenkins, Maven, Master-POMs, SVN, Green Screens)
  - Release content auditing: (I^2T^2) and health check of builds and data
  - Internal release notes
- **Integrated Qualification System**:
  - Requirements definition (Enterprise Architect)
  - Change impact analysis
  - Test Design
  - Test Procedures (TestLink)
  - Test execution automation tool
  - Test scripts
  - Test Results
  - Requirements Verification and Traceability Matrix (RVTM)
  - Comprehensive Test Reporting (Dashboard)

Key ‘creating system’ elements (Technical and Tooling) cont...

- **System non-functional qualification infrastructure**:
  - System probes and monitoring framework (Tivoly, Hyperic)
  - Performance and load test scripting and execution framework (J-Meter, Squirrel, LoadUI)
- **System Processing Visualisation** (custom tool)
- **System Error reporting and transaction logging** (Issue diagnosis and resolution efficiency) (SMC)
- **Data Management infrastructure**:
  - Data Management Tool (DMT)
  - Extraction, Translation, Validation, Enrichment, Loading (ETL+) scripts and processing (to achieve alignment with WCO data model)
- **Infrastructure** to **support transitioning of product** into Production:
  - Compare tool (Automated Production parallel run comparison processing and reporting)
  - Adaptable Comparison Analysis reporting framework (Excel pivot table system)
  - Parallel Assistent Tool (PA Tool): Interrogation of parallel systems of systems for end-to-end transaction information
  - Production Replay Tool: Simulating full production environment on individual system-system interaction level, i.e. external system behaviour per production transaction, to reproduce exactly a production scenario

The realities of working on the iCBS system


LET ME KNOW WHICH GROUP I SHOULD STOP WORKING ON.
ESSENTIAL
CRITICAL
MUST-HAVE
www.dilbert.com
scottadams@aol.com
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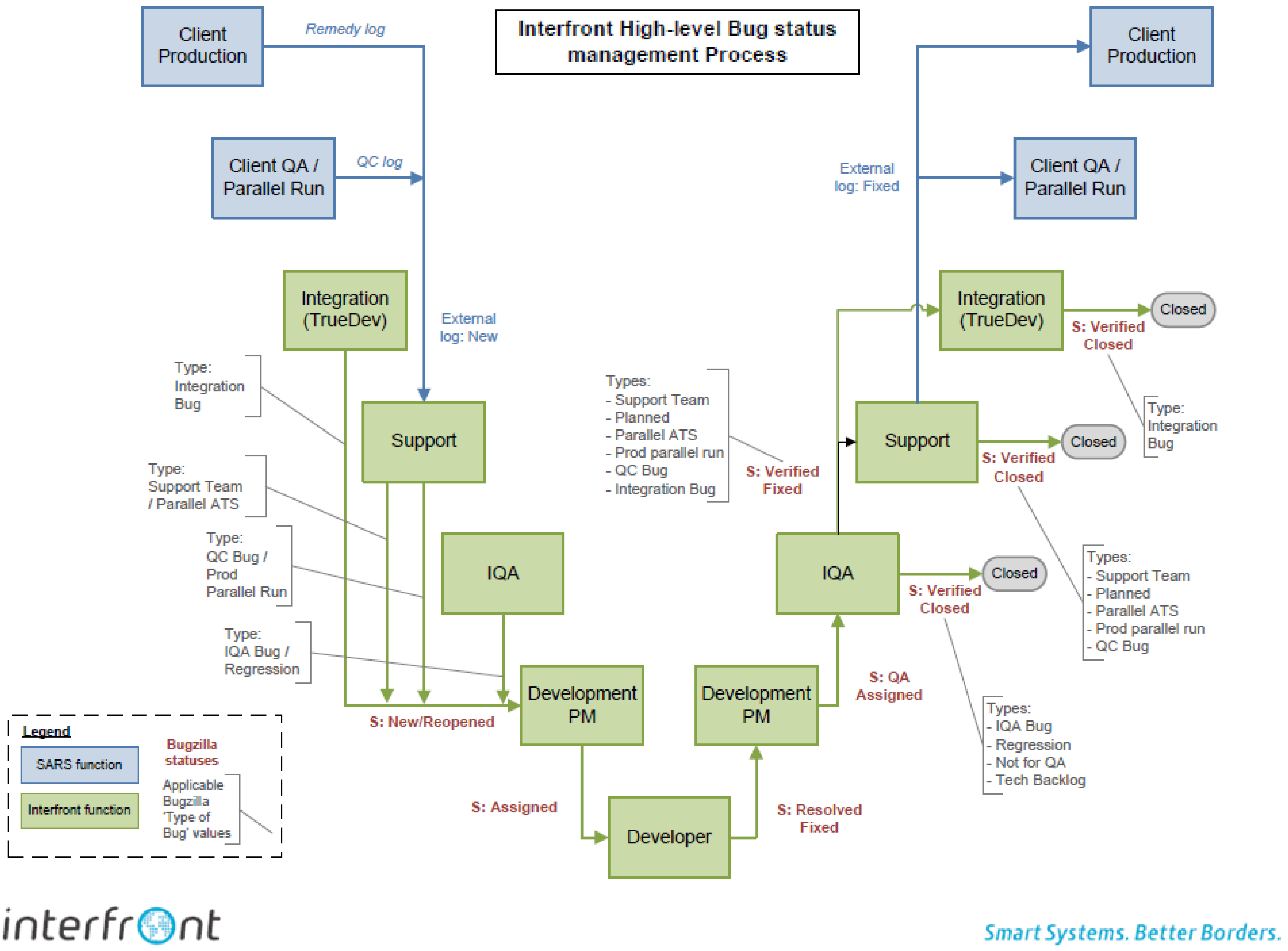
Interfront High-level Bug status management Process
Client Production
Remedy log
Client QA / Parallel Run
QC log
Integration (TrueDev)
External log: New
Support
Type: Integration Bug
Type: Support Team / Parallel ATS
Type: QC Bug / Prod Parallel Run
Type: IQA Bug / Regression
IQA
Development PM
S: New/Reopened
S: Assigned
Developer
S: Resolved Fixed
Development PM
S: QA Assigned
IQA
S: Verified Closed
Closed
Types: - IQA Bug - Regression - Not for QA - Tech Backlog
Support
S: Verified Closed
Closed
Types: - Support Team - Planned - Parallel ATS - Prod parallel run - QC Bug
Integration (TrueDev)
S: Verified Closed
Closed
Type: Integration Bug
Types: - Support Team - Planned - Parallel ATS - Prod parallel run - QC Bug - Integration Bug
S: Verified Fixed
External log: Fixed
Client QA / Parallel Run
Client Production
Legend
SARS function
Interfront function
Bugzilla statuses
Applicable Bugzilla 'Type of Bug' values
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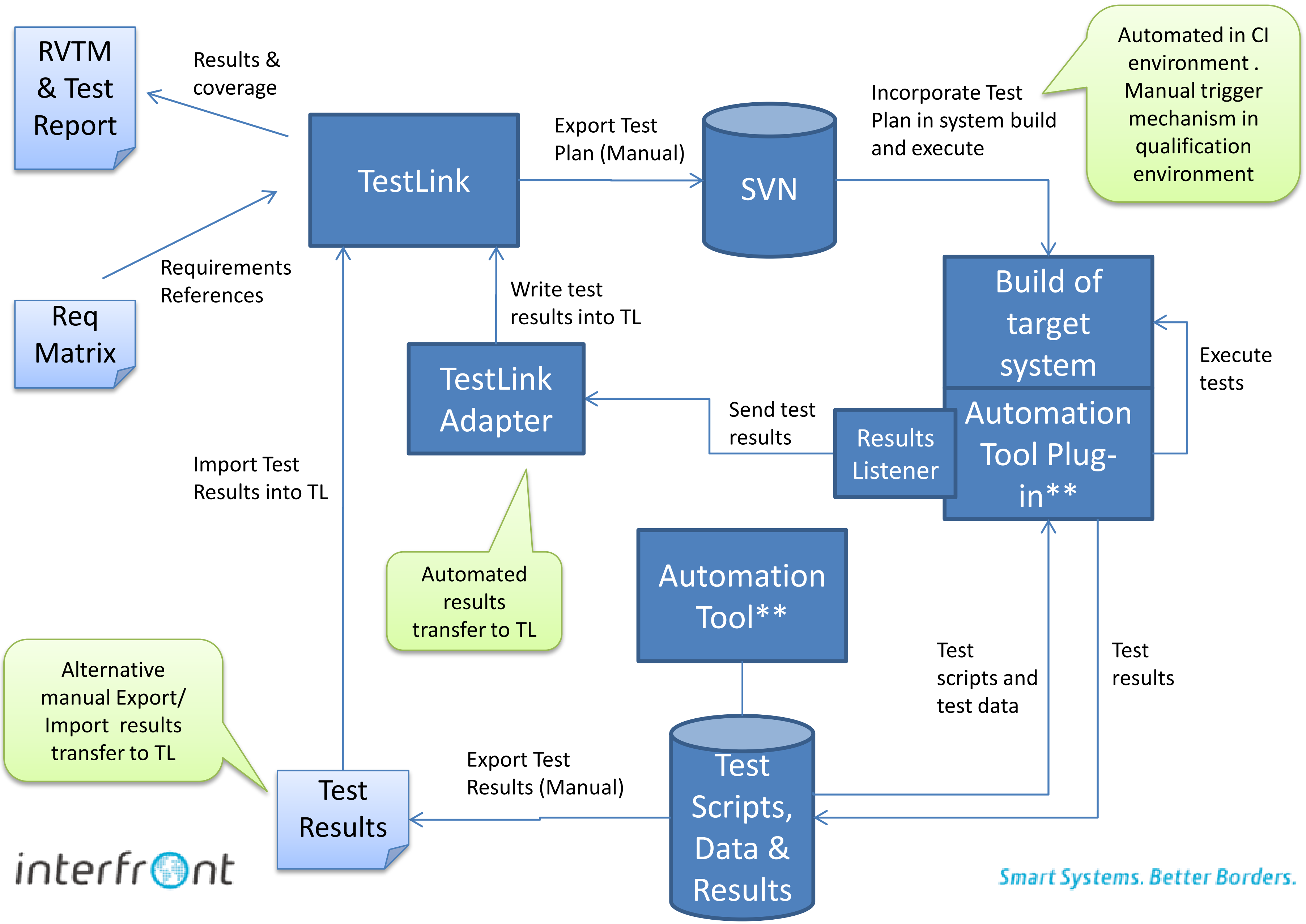
Integrated Qualification system



RVTM & Test Report
Results & coverage
TestLink
Export Test Plan (Manual)
SVN
Incorporate Test Plan in system build and execute
Automated in CI environment . Manual trigger mechanism in qualification environment
Requirements References
Req Matrix
Write test results into TL
Build of target system
Execute tests
TestLink Adapter
Send test results
Results Listener
Automation Tool Plug-in**
Import Test Results into TL
Automated results transfer to TL
Automation Tool**
Test scripts and test data
Test results
Alternative manual Export/ Import results transfer to TL
Export Test Results (Manual)
Test Results
Test Scripts, Data & Results

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Twelve Principles of Agile SW Development

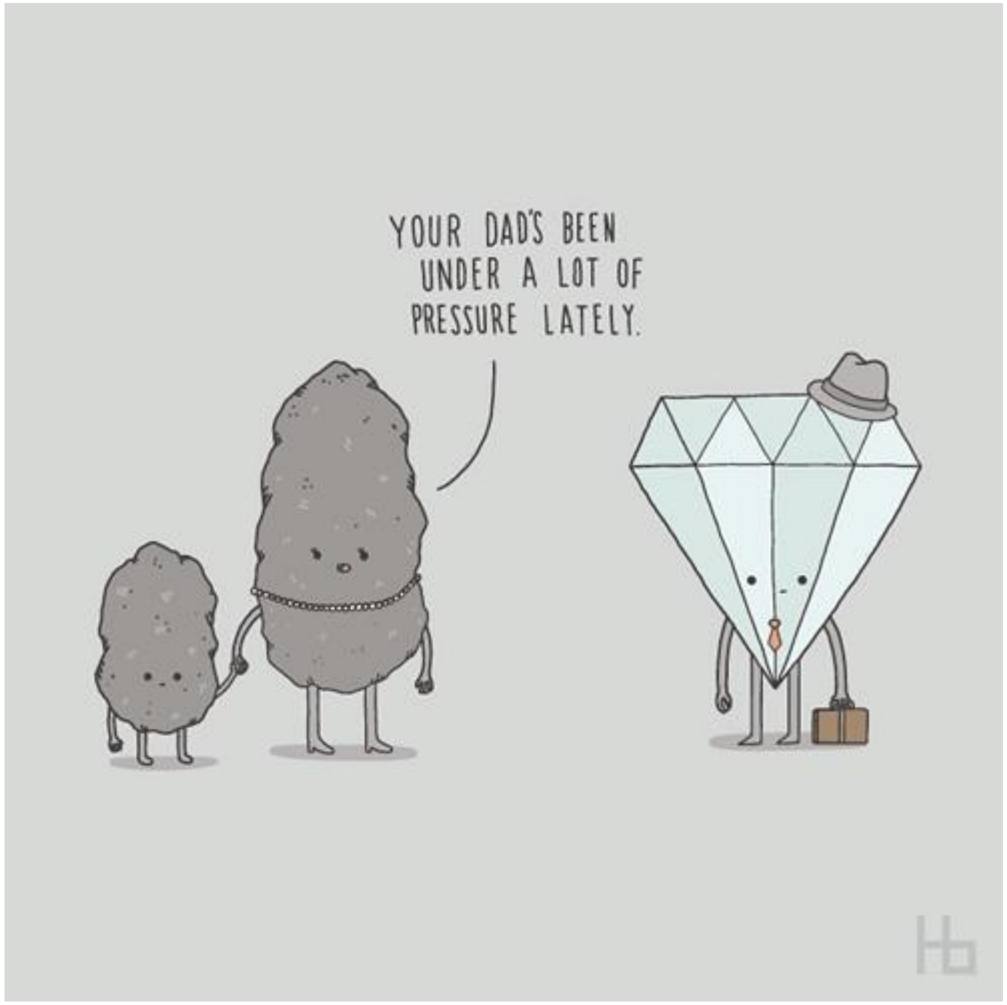
1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software: **Daily full system deploy**
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage: **Daily prioritisation of new development items**
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale. **Daily full system deploy**
4. Business people and developers must work together daily throughout the project. **Daily through systems engineering teams and program management**
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done. **Self-organising teams**
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation. **Daily communication rhythms, open plan, Skype groups**

Twelve Principles of Agile SW Development cont...

7. Working software is the primary measure of progress. **Continuous integration – full regression testing with results**
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely. **Multiple releases/week with stable baselines over months (Major system changes included)**
9. Continuous attention to technical excellence and good design enhances agility. **Collaborative, continuous design function – SE&DA**
10. Simplicity--the art of maximizing the amount of work not done--is essential. **As simple as needed, and not simpler. Making things *simple* in a large development is not *easy*.**
11. The best architectures, requirements, and designs emerge from self-organizing teams. **Yes**
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly. **Retrospectives, Roles dedicated to improving efficiencies and ways of work (DevOps, Org systems engineer). Continuous pressure to up performance.**

[Source: Agile Aliance: http://www.agilealliance.org/the-alliance/the-agile-manifesto/the-twelve-principles-of-agile-software/]

Key ingredient #1: Pressure creates diamonds...



Key ingredient #2: If nothing makes sense, make fun...

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ANDERSON
"This Venn diagram tells us nothing, but it's *so cute!*"

Thank You!

Questions / Comments?

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