Mission Assurance Manager (MAM) Life Cycle Risk Management Best Practices

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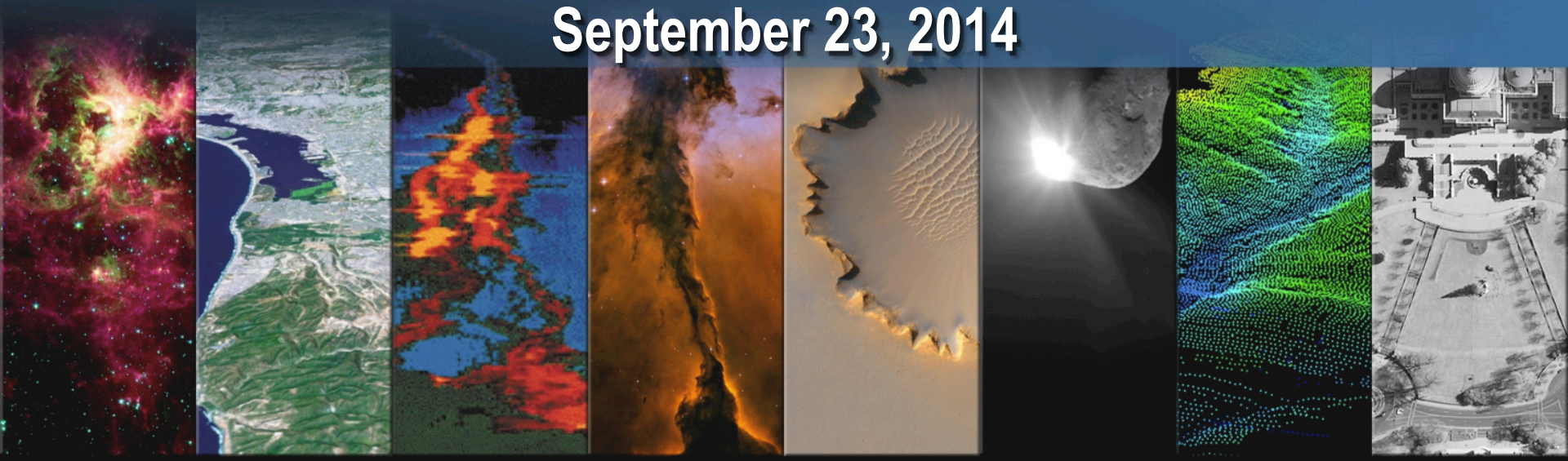


Agility to Innovate, Strength to Deliver

Ball Aerospace & Technologies Corp.

MAM Risk Management

- Challenges in Risk Management
- Program Risk Lexicon
- Independent Risk Management
- Mission Class Risk Strategies
- Managing Development Lifecycle Risk

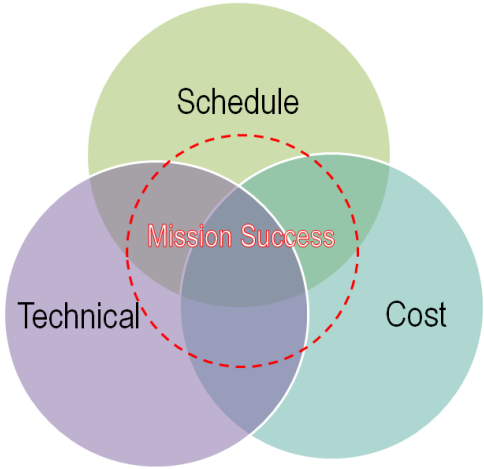
Challenges in Risk Management

- **Affordability Demands**
  - Affordability initiatives reducing cost but not complexity
  - Mission Assurance has to do more with less
- **Normalcy Bias: Lack of exposure to failure and small sample size of operating hours:**
  - Rejection of proposed failure modes
  - Seizing on any ambiguities to infer less credibility
  - Interpretation if warnings in the most optimistic way.
- **Bounded rationality: Decision-making, rationality of individuals is limited by**
  - Information
  - Cognitive state
  - Finite decision times (Herbert A. Simon)
- **Epistemic failures due to erroneous technological assumptions, even thought there were good reasons to hold that assumption. (John Downer)**
  - Unvalidated methods or environments

Ensure Consistency in the Program Risk Lexicon

- **Risk communication from MAMs to SMEs to program teams**
  - **Risk Timing**
  - **Elements of Risk**
  - **Risk Categories**
  - **Risk Types**
  - **Process**
- **"IF-THEN" focused Risk Process**
  - **Specifics of triggering and undesirable events**
- **Risk Matrixes**
  - **Communication and action**
  - **Defined likelihood and impact criteria**
- **Program Risk Mitigation**
  - **Risk profile driven**
  - **TRL/MRL tailored**

Timing: Risks vs. Issues
Elements: Likelihood & Impact
Categories: Active, Accepted, Retired
Process: Risk & Opportunities
Types: Mission Success, Implementation, Programmatic, and Technical



The Risk Lexicon is our Foundation for Effective Risk Management

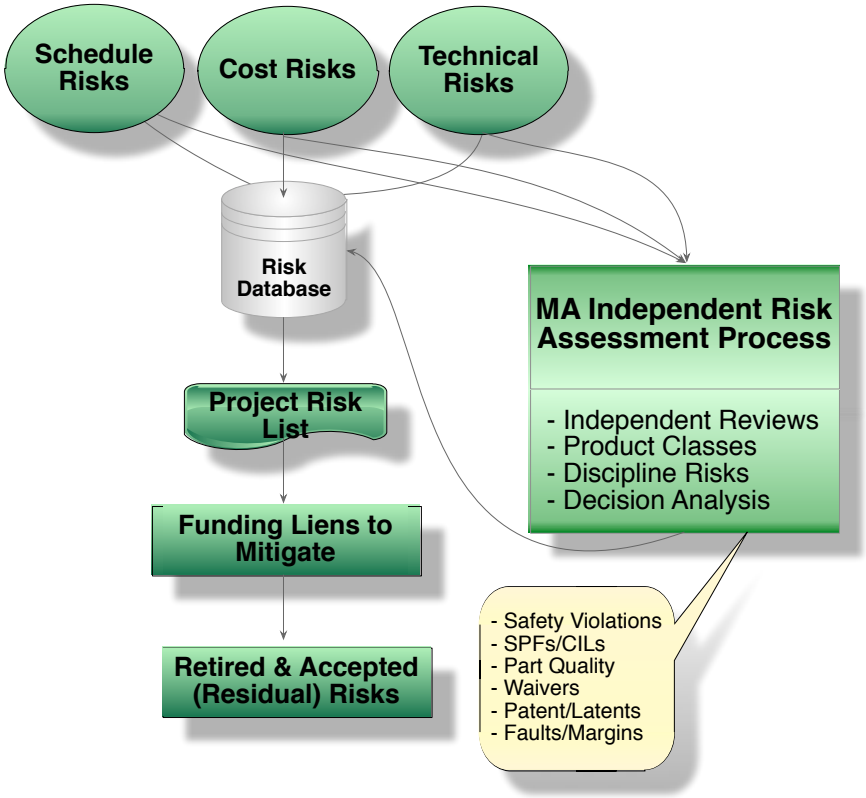
Uncertainty Management: Management of the "UNKNOWNS"

Retired Risks	No Residual Risk	Artifacts
Known-Knowns *Risk Artifacts*	• Test as you Fly Validation • Demonstrated TPM Performance • Flight or test-validated analysis, simulations and models	• Incremental knowledge Buildup • Complete verification and validation
Open Risks	**Open Residual Risks**	**Risk Handling**
Known-Unknowns *Accepted Risk*	• Analysis / test limitations • Unverified Models/Simulations • Envelope expansion • Unverified failure modes	• Evaluate Deltas due to ○ Baseline limitations ○ Margin gaps ○ In-complete V&V ○ Analysis thoroughness
Unknown-Knowns *Execution Risk*	• Miscommunicate test/analysis • Understanding of data/ envir • Poor documentation combined with loss of corporate memory	• Program communications / data sharing • Incremental knowledge build-up w/ trending
Unknown-Unknowns *Hidden Risk*	• Bad assumptions • Unfinished foundation research • Untested new environments • Inadvertent operations outside of limits	• TRL level 6 by PDR • Envir analysis/test rigor • Sim & test-beds fidelity, TAYF • Design Margins

MAM must work to mitigate the largest classes of unknowns

MAM Independent Risk Management

- **Program RM captures all risks using program reserves to eliminate/mitigate risks**
  - Mitigates Risk to Accepted/Retired
- **MA Independent Risk Assessment**
  - Big picture of risk profile vs. Product Class
  - Technical risk with cost & schedule constraint focus
  - Discipline exception evaluation for program risk inclusion
  - Periodic review of early project decisions
    - e.g. Single point failures for continued validity
  - Integral subset of program risk process
- **Risk Sources**
  - Failure Modes, SPFs, Quality & Pedigree
  - Process capability, Patent & Latent defects
  - Hazards, Fault Intolerance, Margins



Coordinated MA Process/Product Assessment of Risk to Mission Success

Managing Risk Across Product Classes

- **Mission Success measured from full compliance to minimum threshold performance**
- **Unique risk exposure and dominant risk**
- **Process and Product Architecture trades balance risk inline with program risk strategy**

Mission Risk Class	Class A	Class B	Class C	Class D
Ball Internal Product Class (Pre-Tailored)	**Class 1** Operational *(User/Product Driven)*	**Class 1**: *Operational* **Class 2**: *Commercial*	**Class 3** (Streamlined Heritage)	**Class 4** *(ALT Margins, Safety)*
Mission Success	Full Compliance	Equivalent Compliance	Threshold Performance	Minimum Threshold
Product Class Managed Risk	• >> Mission Length • Custom Developed • Prescriptive "How To" • >> Assurance Artifacts • Resource Balance	• > Mission Length • Heritage Developed • Requirements Volatility • Trusted Suppliers • > Assurance Artifacts	• < mission length • Heritage developed • MA Surgical Focus • RE Decision Authority • Audit Process Integrity	• << mission length • Board subsystems • Microsat/Prototype • ALT Based Assurance • Supplier Stability • << Empirical Data

Class Dominant Risk Drivers Focus MA and Program Risk Efforts

Tailoring Ensures Customer Risk Expectations Achieved

- **Product Classes reduce gap between customer expectations and Ball baselines**
  - Each product class serves as the minimum floor for process requirements
  - Supplemental tailoring closes remaining gaps to ensure full compliance
- **Four techniques formulated to facilitate this risk balancing tailoring:**
  - Process application level evaluation of isolation regions
  - Rigor trades of process capability, test coverage, residual risk
  - Oversight vs. Insight and transparency
  - Relationships among mission success assurance techniques and products

Description	Process Execution Tailoring Drivers			
Tailoring Method	Level	Rigor	Oversight	Relationships
Core principles	• Application Level • Isolation Boundaries • Compliance • Graceful Degradation	• Methods Used • Depth Applied • Standard Compliance • Acceptable Residual	• External Oversight • Oversight/Insight • Internal Independent • Self Governance	• Overlap degree • Internal/External faults • During Development • In Operation

Optimizing the Risk Strategy Inline with Mission and Programmatic Constraints

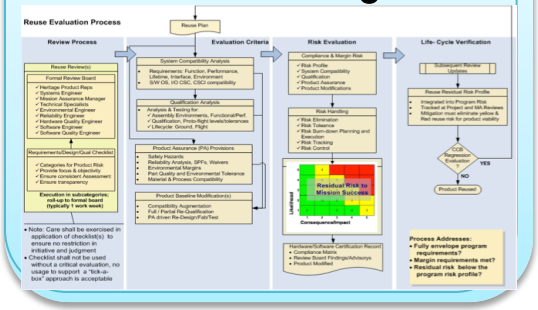
Lifecycle Risk Products Capture Development Phase Risks

Architectural Optimization

Category	Process
Program Execution	1 Design Assurance 2 Requirement Analysis and Validation 3 Parts, Materials and Processes 4 Environmental Compatibility 5 Reliability Engineering 6 System Safety 7 Configuration/Change Management 8 Integration, Test and Evaluation
Risk, Oversight and Assurance	9 Risk Assessment and Management 10 Independent Reviews 11 Hardware Quality Assurance 12 Software Assurance 13 Supplier Quality Assurance
Triage, Information & Lessons Learned	14 Failure Review Board 15 Corrective/Preventative Action Board 16 Alerts, Information Bulletins

- Critical Evaluation
- Process Tailoring

TRUE Heritage



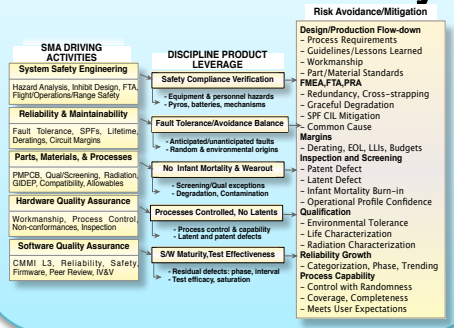
- Review, Criteria, Risk
- Life-cycle Verification

Next Step Readiness

Review Items	I&TRV Assessment
- Drawings, Specs, Engineering - Change Proposals - PFS, SOW, ICD's - Waivers, MRB/FRB Results - Previous Unit Risks - Environmental Test Results - Reliability/Parts/Design Analysis - Telemetry/Calibration Data - Mass Data - Operational/Handling Constraints	- Adequate Compliance Testing - STE and Documentation Readiness - Waivers/Liens Closure Plan - Receiving Organization Readiness - Pre-integration Critical Items - Operations and Handling Constraints

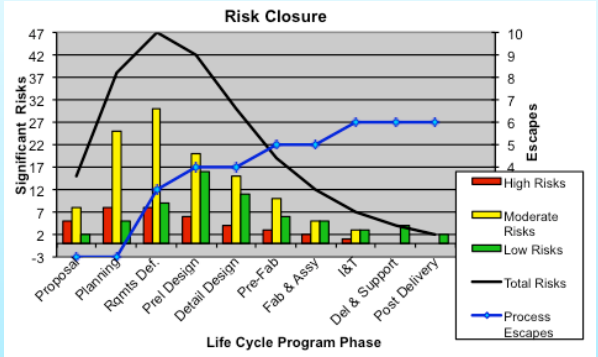
- Requirement Sell-Off
- Integration Readiness

Residual & Uncertainty



- Accepted, Execution, Hidden Uncertainty
- Exceptions Management

Cumulative Risk Management



- Risk Profile Management
- Metrics: ID, Efficacy, Escapes

Anomaly Risk Ratings

Failure Effect Rating (excluding redundancy)		Failure Cause/Corrective Action Rating	
Severity	R	R	Cause/Corrective Action
Negligible (N)	1	1	**Known** cause/**certainty** of corrective action (*No residual risk*)
Significant (S)	2	2	**Unknown** cause/**effective** corrective action (*No residual risk*)
Catastrophic (C)	3	3	**Known** cause/**uncertainty** in corrective action (*Some residual risk*)
High Priority		4	**Unknown** cause/**uncertainty** in corrective action (*Residual risk*)

- Resource Prioritization
- Residual Burn-down

MAM Risk Management Focused On Bounding Sources of Uncertainty

- Analyzing the Challenges
- Ensuring Consistency in Execution
- Maximizing the Unique Perspective of MA
- Controlling Dominant Mission Class Risks
- Closing the Gap to Customer Expectations

- Using Appropriate Life Cycle Tools to Capture Risk Aligned with Development