# NCSX Project
# Risk Management
# &
# Contingency Analysis

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March 13, 2008

# Topics Addressed

- Background -- History and Current Status of NCSX Risk Identification and Analysis
- NCSX Risk Management Process
- NCSX Contingency Analysis Process and Model
- Draft Contingency Analysis Results to Support BCP Submittal for NCSX Project

# Background - 1

- Earlier practice on project was somewhat informal – "Critical Issues List"
  - All risks not identified, assessed, and tracked
  - Risk Mitigation not formally identified/managed
  - Near term and even real time focus on risk mitigation as compared to project life cycle perspective
- Increased focus on formal Risk Management during 2007
  - Initial Risk Register developed and used to estimate contingency in August 2007 estimate. (Risk contribution was small compared to uncertainty contribution.)
  - Risk register evolved for last ~6 months (e.g., risks were added, downgraded, and retired) but did not play a strong central role as a management tool. Failed to avoid large delays and cost growth as some risks were realized.
  - Root cause: inadequate initial risk identification.

# Background - 2

- Much more emphasis on Risk Management in 2008
  - Revised Risk Management Plan
  - More focused risk identification and assessment process was completed.
    - Analyzed causes of past cost and schedule problems in considering future risks.
    - More systematic approach to ensure that all important risks are identified and “owned” by job managers and project office.
    - More attention to mitigation. Tasks identified, planned and tracked.
    - Result: risk register better captures project risks and mitigation plans. Will be more useful as a management tool.
  - Quantitative Analysis to support contingency estimate
    - Risk element is larger contributor to contingency now
  - Project management team committed to keeping focus on risks as project moves forward

| Problems already encountered on NCSX (or previous Projects) | |
|---|---|
| | **Risk** |
| **Procurement issues** | |
| | Major procurement vendor delays<br>MCWF: 24-->33 mos. (38%)<br>VVSA: 14 --> 24 mos. (71%)<br>TF: 18-->30 mos. (67%) |
| | Assembly held up by delayed or non-conforming parts<br>Chill plates<br>Alumina shims<br>MCWF<br>PF coils out-of-round (NSTX, TFTR) |
| | |
| **Design issues** | |
| | Designs had to change<br>Hard tubing on VV<br>Inboard shim design<br>Alumina shims. |
| | Assembly cost and schedule grew as assembly sequence plan matured:<br>Steady trend in 2007-08 |
| | |
| **Manufacturing operations issues** | |
| | Metrology delays due to equipment problems or anomalous results<br>MC metrology anomalies- Feb. '07<br>MC Romer arm problems- Nov '07<br>FPA laser tracker anomalies- Oct. '07 |
| | Modular coil fabrication costs grew even after FDR and completion of twisted racetrack R&D coil. |
| | |
| **Machine operations Issues** | |
| | Cooldown problems during cold test of TRC and C1 modular coil. |
| | Vacuum leaks (e.g., ATF) |
| | Field Errors detected in e-beam tests<br>ATF (~6 months delay) |
| | |
| **Organizational Issues** | |
| | Loss of key indviduals from leadership positions has impacted schedule. Delayed critical design tasks. |

**Past problems were analyzed for relevance to future risks.**

- Cost & schedule growth as assembly sequence plan matures is still a risk.
- Cost growth in mfg. operations is now better appreciated and included in base estimates and uncertainty.
- Future procurements have more float, making critical path impacts less of a risk than in the past.

# Risk Management Process

- Generally follows standard DOE guidance and practice
  - Evaluates events or conditions that may or may not happen or be realized over the life of the project
  - Both Threats and Opportunities addressed
- Key Elements:
  - Establish Bounding Assumptions
  - Risk Identification
  - Risk Assessment
  - Risk Mitigation
  - Quantitative Analysis
  - Risk Documentation and Tracking/Reporting

# Bounding Assumptions

- Funding Availability
- Constant PPPL state of operations/overheads
- No extraordinary incidents, stand downs or lab shutdown
- No change to CD-4 Completion Criteria
- Risks with very low likelihood of occurrence but high impacts/consequences excluded

# Currently Excluded Risks

- Major technical events requiring disassembly of the machine or a field period.
- Damage requiring re-fabrication of a coil. (But damage requiring re-work in accessible areas, e.g. cooling tubes and leads, is covered.)
- Damage requiring major disassembly and reassembly of a field period. (But disassembly / reassembly of individual joints during assembly is covered.)
- Failure of a key component or system during integrated system testing.
- Large islands detected during e-beam mapping requiring extensive troubleshooting and remediation.

# Risk Identification

- Collective effort by key members of NCSX Project Team, coordinated by NCSX Integration Manager and System Engineering Support Manager
- Risks identified by groupings:
  - Management and Organizational Risks
  - General Assembly Risks
  - Technical Risks, subdivided by Assembly Station
  - Start-up Risks
  - Technical Risks – components and systems

# Risk Assessment

- Qualitative Risk Ranking based on assessments of likelihood of occurrence and estimated impacts or consequences
- Current Number of Risks
  - 2 High Risks
  - 16 Moderate Risks
  - 62 Low Risks

# Likelihood of Risk Occurrence

| Classification | Probability of Occurrence |
|---|---|
| Very Likely (VL) | P≥ 80% |
| Likely (L) | 80%< P ≥ 40% |
| Unlikely (U) | 40% < P ≥ 10% |
| Very Unlikely (VU) | 10% < P ≥ 1% |
| Not Credible (NC) | P < 1% |

# Risk Consequences

| Impacts | Negligible | Marginal | Significant | Critical | Crisis |
|---|---|---|---|---|---|
| **Technical** | **No impact of performance** | **Minor degradation of performance** | **Moderate degradation of performance** | **Moderate degradation of performance** | **Desired performance in doubt** |
| **Cost** | **< $100K** | **≥$100K** | **≥$500K** | **≥$1M** | **≥$5M** |
| **Schedule** | **<0.5 Months** | **≥0.5 Months** | **≥1 Months** | **≥3 Months** | **≥ 6 Months and will impact CD-4** |

# Risk Ranking Matrix

| | Negligible | Marginal | Significant | Critical | Crisis |
|---|---|---|---|---|---|
| **Very Likely** | Low | Moderate | High | High | High |
| **Likely** | Low | Moderate | Moderate | High | High |
| **Unlikely** | Low | Low | Moderate | Moderate | High |
| **Very Unlikely** | Low | Low | Low | Moderate | High |
| **Non Credible** | Low | Low | Low | Low | Low |

# Risk Mitigation

- Mitigation strategies identified for all risks, to extent feasible and practical
- Risk mitigation activities included in Cost Estimates and Resource Loaded Schedule
- Schedule logic adjusted as appropriate to accomplish mitigation (e.g., accelerated design activities)
- Risk mitigation status tracked regularly and updated status reported periodically

# High Risks

| Risk No. | Affected Jobs | Description | Mitigation Plan |
|---|---|---|---|
| Assy-2 | 1815 | Station 5: cost and schedule grows when Assembly Sequence Plan fully matures | Expedite Component Designs and Assembly Sequence Plan<br>Jobs 1354, 1501, 1601, 8203 |
| Assy-3 | 7503 | Station 6: cost and schedule grows when Assembly Sequence Plan fully matures | Expedite Component Designs, Plant Layout, and Assembly Sequence Plan<br>Jobs 1701, 1702, 1803, 8215 |

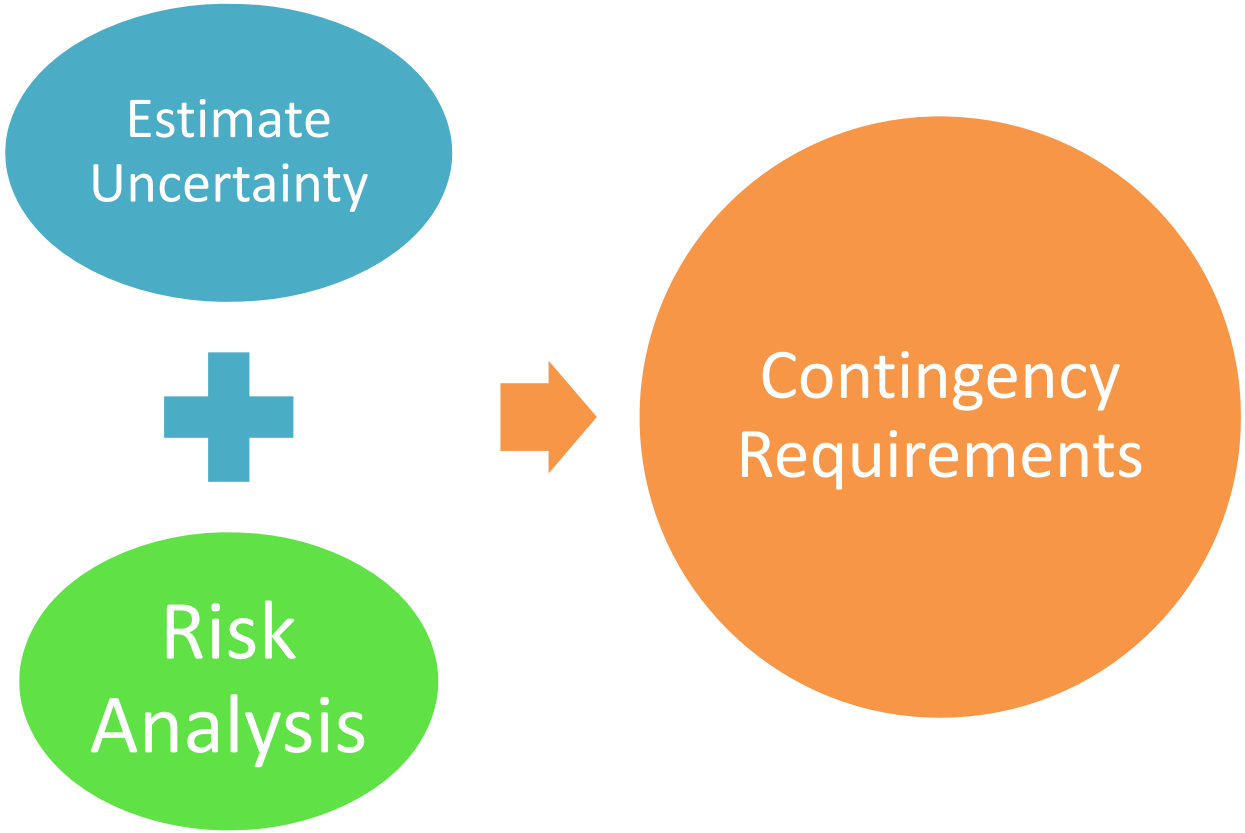
# Quantitative Analysis

- Estimates made of risk impacts – increased costs and critical path extensions
- Risk likelihood and impacts used in probabilistic risk analysis model and results incorporated into contingency analysis and estimates

# Risk Documentation and Reporting

- Risk Register is key reporting tool
- Elements included in Risk Register:
  - Description of risk (threat or opportunity)
  - Jobs affected (where impacts will be realized)
  - Mitigation Plans
  - Deadline to retire risk or realize impacts (trigger)
  - Risk Owner
  - Current Status
  - Qualitative Risk Assessment (likelihood, consequences, ranking)
  - Cost and Schedule Impacts and Basis of Estimate

# Contingency Analysis




**Probabilistic Contingency Analysis Model (Crystal Ball®)**

# Estimate Uncertainty

- Inherent uncertainty in cost and schedule estimates based on
  - Design Maturity
  - Design Complexity
- Evaluated for all job estimates (WAFs)
  - Estimated Costs
  - Critical Path Schedule Activities
- Includes factor for overall process errors and omissions (ranged from -1% to +3%)

# Design Maturity

| | |
|---|---|
| High | Final design available. All design features/requirements well known. No further design development or evolution expected that will impact estimate |
| Medium | Preliminary design available. Some additional design evolution likely. Further developments can be somewhat expected or anticipated and reflected in estimate |
| Low | No better than conceptual design basis currently available. Design details, procedures, etc. still need much development and evolution of requirements beyond estimate basis is likely and expected |

# Design Complexity

| | |
|---|---|
| Low | Work is fairly well understood -- either standard construction or repetition of activities performed in past. Little likelihood of estimate not being well understood and requirements not being well defined |
| Medium | More complex work requirements that have potential to impact cost and schedule estimates. Limited experience performing similar tasks, so ability to estimate accurately is somewhat suspect |
| High | Extremely challenging tasks and/or requirements. Unique or first-of-a-kind assembly or work tasks. No good basis for estimating work exists so there is a high degree of estimate uncertainty |

# Estimate Classification

| Estimate Class | Level of Definition | Accuracy Range | NCSX Definition |
|---|---|---|---|
| 5 – ROM<br>(DOE CD-0) | 0-2% | Low:-20% to -50%<br>High: +30% to +100% | L Maturity<br>High Complexity |
| 4 – Conceptual<br>(DOE CD-1) | 1-15% | Low:-15% to -30%<br>High: +20% to +50% | MH and LM |
| 3 – Preliminary<br>(DOE CD-2) | 10-40% | Low:-10% to -20%<br>High: +10% to +30% | LL, MM and HH |
| 2<br>(DOE CD-2 or 3) | 30-70% | Low:-5% to -15%<br>High: +5% to +200% | ML and HM |
| 1 – Definitive<br>(DOE CD-3) | 50-100% | Low:-3% to -10%<br>High: +3% to +15% | H Maturity<br>L Complexity |

# NCSX Estimate Ranges

| | | Design Complexity | | | | | |
|---|---|---|---|---|---|---|---|
| | | Low | | Medium | | High | |
| Design Maturity | Low | -15% | +25% | -20% | +40% | -30% | +60% |
| | Medium | -10% | +15% | -15% | +25% | -20% | +4-% |
| | High | -5% | +10% | -10% | +15% | -15% | +25% |

# Risk Analysis

- Probability of Occurrence used to determine if events occur or risks/opportunities realized

| Category | Uniform Probability Distribution Range |
|---|---|
| Non-Credible | 0 to 0.01 |
| Very Unlikely | 0.01 to 0.1 |
| Unlikely | 0.1 to 0.4 |
| Likely | 0.4 to 0.8 |
| Very Likely | 0.8 to 1.0 |

- When simulation determines a risk will occur, uses Estimated Cost and Schedule (Critical Path) Impacts

# Schedule Impact Mitigation

- Model assumes 2nd shift operations when possible and needed (if simulation determines schedule needs to be extended)
- Schedule Contingency results reduced by assuming work on Saturdays
- Mitigation Costs added to contingency requirements
  - 2nd Shift and Saturdays Oversight and Support differential

# Costs of Schedule Extension

| JOB | Description | Cost/yr | Cost/mo. |
|---|---|---|---|
| 1802/1810/7401/7501 | Field Period Assy & Machine assy (average of 2 assembly ops) | 2376 | 198 |
| 1901 | Stellarator core management | 504 | 42 |
| 8101 | PPPL Management | 912 | 76 |
| 8102 | ORNL Management | 312 | 26 |
| 8202 | Engineering mgt | 792 | 66 |
| 8203 | Design Integration | 660 | 55 |
| 8204 | Systems Analysis | 132 | 11 |
| 8205 | Dimensional control | 60 | 5 |
| 8215 | Plant Design | 60 | 5 |
| 8998 | Allocations | 492 | 41 |
| **Total** | ($k/month) | | 525 |

# NCSX Critical Path

| Schedule Activity | | | | Base Duration (mos) on Critical Path |
|---|---|---|---|---|
| ***CP (within 1/2 month of CP)*** | | **start** | **finish** | |
| Job -1810 Field Period Assembly Stations 1,2,3 | Station 2 MC Sub-assy A1/B1/C1 | 2/1/2008 | 11/18/2008 | 9.6 |
| | Station 2 MC Sub-assy A3/B3/C3 | 11/18/2008 | 4/13/2009 | 4.8 |
| | Station 2 MC Sub-assy A6/B6/C6 | 4/13/2009 | 11/3/2009 | 6.7 |
| | Station 3 Assemble Mod Coils and VVSA FP#3 | 11/3/2009 | 3/24/2010 | 4.6 |
| Job - 1815 Field Period Assembly Station 5 | Station 5 Final Assembly FP#3 | 3/24/2010 | 8/11/2010 | 4.6 |
| Job 7503 Final Machine Assembly (Station 6) | | 8/11/2010 | 11/11/2011 | 15.0 |
| Job 8501 - Integrated System Testing | | 11/11/2011 | 12/13/2011 | 1.1 |
| | | | | |
| | | | | 46.4 |

# Contingency Analysis Results

| | 90% Confidence | | | 80% Confidence | |
|---|---|---|---|---|---|
| **Base Schedule** | **46.4** | **months** | | **46.4** | **months** |
| | | | | | |
| Schedule Uncertainty Contingency | 8.1 | | | 6.5 | |
| Risk Schedule Contingency | 11.3 | | | 10.0 | |
| | | | | | |
| ***Total Schedule Contingency (90%)*** | ***19.4*** | ***months*** | | ***16.5*** | ***months*** |
| | | | | | |
| | | | | | |
| **Base ETC** | **61,647** | | | **61,647** | |
| | | | | | |
| Contingency (Std Uncertainty) | 9,140 | 15% | | 8,360 | 14% |
| Cost of Schedule Uncertainty Contingency | 4,260 | 7% | | 3,410 | 6% |
| Cost of Schedule Mitigation (incl. 2nd Shift & Saturday | 260 | 0% | | 230 | 0% |
| | | | | | |
| ***Total Uncertainty Contingency*** | ***13,660*** | ***22%*** | | ***12,000*** | ***19%*** |
| | | | | | |
| Risk Cost Contingency (from Risk Model) | 2,880 | 5% | | 2,630 | 4% |
| Risk Schedule Contingency (cost of stretch) | 7,130 | 12% | | 5,240 | 9% |
| | | | | | |
| ***Total Risk Contingency*** | ***10,010*** | ***16%*** | | ***7,870*** | ***13%*** |
| | | | | | |
| ***Total Cost Contingency*** | ***23,670*** | ***38%*** | | ***19,870*** | 32% |
| | | | | | |
| **ETC with Contingency** | **85,317** | | | **81,517** | |

# Contingency by Year

- Spread cost contingency based on schedule for jobs that contribute to most uncertainty and based on jobs where most risk impacts will be realized (used sensitivity analysis)
- Assigned all cost associated with schedule contingency to 2012
- Slightly more conservative (i.e., front loaded) than analysis indicates as appropriate

# Proposed Spread of Contingency

| Contingency Spread by Year | | $M | | | $M |
|---|---|---|---|---|---|
| | | 90% | | | 80% |
| 2008 | 10% | 2.37 | | 10% | 1.99 |
| 2009 | 15% | 3.55 | | 15% | 2.98 |
| 2010 | 15% | 3.55 | | 15% | 2.98 |
| 2011 | 15% | 3.55 | | 15% | 2.98 |
| 2012 | 45% | 10.65 | | 45% | 8.94 |
| | | | | | |
| **Total** | | **23.67** | | | **19.87** |

# Concluding Observations

- NCSX Project Team now "gets it" – really focused on identifying, mitigating and managing risks
- Contingency requirements derived from analysis of both estimate uncertainties and impacts of identified risks
- Probably need some guidance from DOE (OFES and Lehman) as to desired confidence level (80% or 90%) – recent projects use both