Hazard Identification and Risk Assessment during Capital Projects

By: Adel Dakheel
William Bridges
Revonda Tew

For: MEPSC, October 10, 2017, BAHRAIM

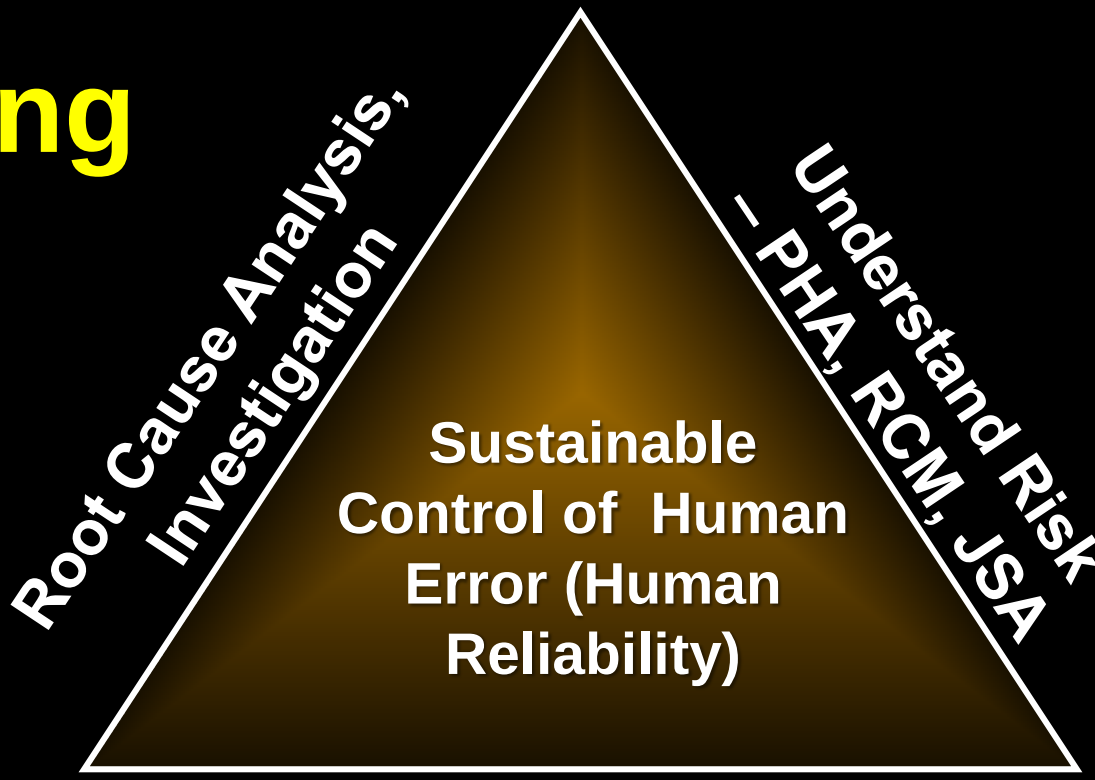
Process Improvement Institute, Inc.
adakheel@piii.com
www.piii.com

Presenter: Adel Dakheel

Process Improvement Institute (PII)

- BS in Biological Systems Engineering
- 16+ years experience in the chemical/petrochemical industry includes Operations, Project Management, Corporate and Consulting
- Experience in SABIC (Jubail Petrochemical Co., Corporate EHSS, Saudi Kayan Petrochemical Co., and Engineering & Project Management). Key player in initial roll-out of SABIC Process Safety Management System (prior to SHEMS)
- 20+ PSM Audits, many Fire Safety Audits, PSM implementation plans (SABIC and PII)
- Led 20+ Unit scale PHAs, 30+ MOC PHAs; scribed on other PHAs (at PII); Participated on numerous Investigations/RCAs (at SABIC and PII)
- Lead Instructor for PSM, RCA, PSM Auditing, PHA Leadership, and other PSM systems

Controlling Risk



Management Systems to Control Human Error/Failures

Management System Level						
	Design Standards	Process Safety Man.	Reliability Systems	TQM & Production Man.	Traditional HSE	Behavior Man.

Implementation Level							
Process/ System Design	Manage Changes & Analyze Risk	Procedures & Training	Proof Documents	Communication	Behavior/ Habit Control	Problem Reporting and RCA	Audits & Performance Measures

History of Risk Assessment & PSM Development during Projects

- Began (in earnest) in mid-1970s in the chemical industry
- Risk assessments & developing PSM during projects widely accepted by mid-1980s and became an element of CCPS's PSM standard

Comparison of PSM Systems

OSHA 29 CFR 1910.119 and EPA 40 CFR 68	AIChE CENTER FOR CHEMICAL PROCESS SAFETY	ACC RESPONSIBLE CARE PROCESS SAEFTY CODE®
Management System	Accountability	*Management Leadership*
Employee Participation†	Process Knowledge and	Commitment/Accountability
Process Safety Information	**Project reviews and design procedures**	Performance Measurement
Process Hazard Analysis		Incident Investigation
Operating Procedures		Information Sharing
Training	Management of Change	CAER Integration
Contractors†	Process Equipment Integrity	*Technology*
Pre-startup Safety Review	Incident Investigation	Design Documentation
Mechanical Integrity	Training and Performance	Process Hazards Information
Hot Work Permit†	Human Factors	Process Hazards Analysis
Management of Change	Standards, Codes and Laws	Management of Change
Incident Investigation	Audits and Corrective Actions	*Facilities*
Emergency Planning and Response	Enhancement of Process Safety Knowledge	Siting
Compliance Audits		Codes and Standards
Trade Secrets		Safety Reviews
		Maintenance and Inspection
		Multiple Safeguards
		Emergency Management
		Personnel
		Job Skills
		Safe Work Practices
		Initial Training
		Employee Proficiency
		Fitness for Duty
		Contractors

Example from Process Improvement Institute, Inc., PSM Course, 2004

History of Risk Assessment & PSM Development during Projects (cont.)

- Many excellent papers have been presented on the topic within AIChE/CCPS (Kelly, Broadribb, McGrath, etc.)
- Some major companies are still weak

Purpose of this Paper

- Summarize the enduring aspects of managing risk during a project
- Highlight some new ways to create and deliver PSM from a project
- Highlight pitfalls to avoid and current best practices

General Concept of Project Risk Management

- Evaluate the risk of a design (for both new or old technology) and ensure there are proper safeguards before startup
- Manage risk from phase-to-phase of a project
- Ensure input of owners/operators
- Ensure project delivers what is necessary to help owners/operators manage risk long-term

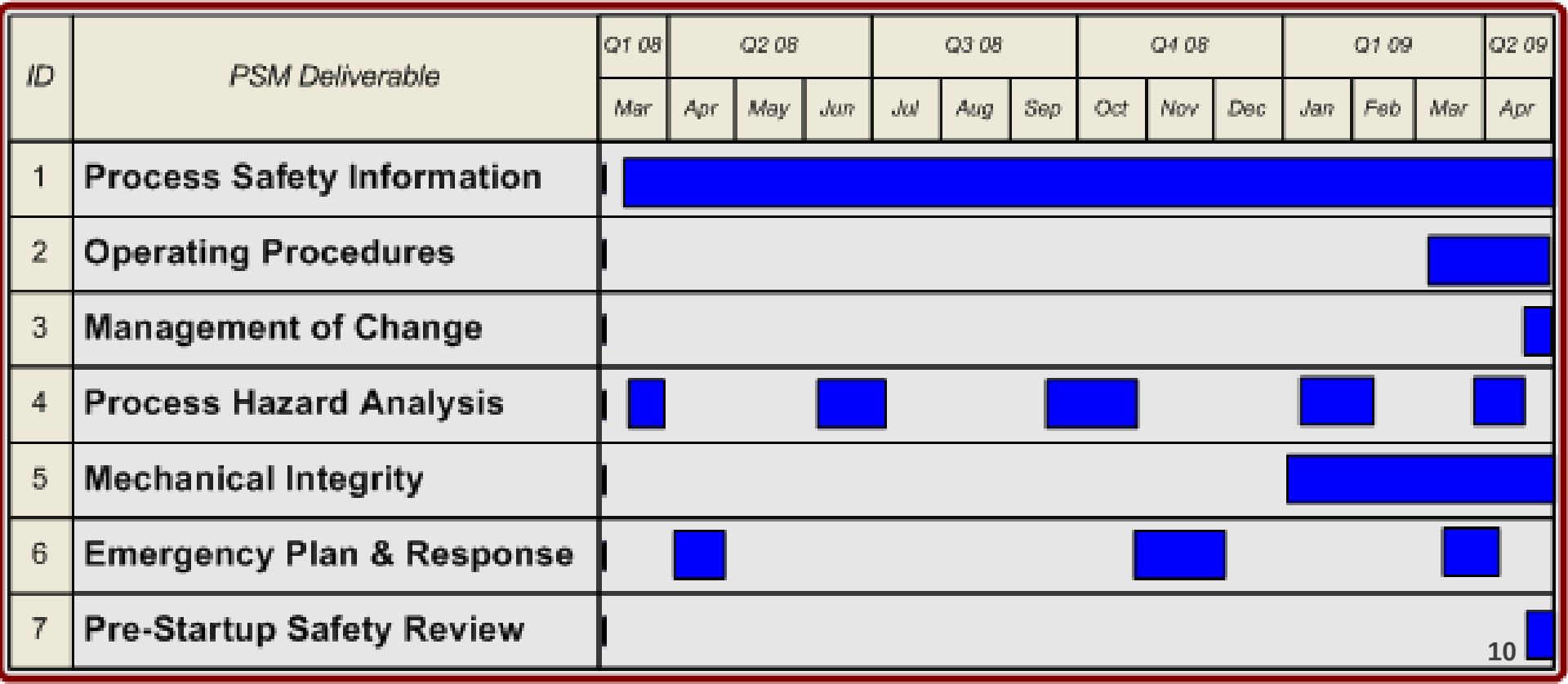
Types of Projects – Size

Project Size	Example Project Scope	Example Project Length/Duration (concept→ commissioning)	Number of Risk Reviews
Major	Major projects handled external to an affiliate/plant, such as expansions and new facilities	12-36 months	4-7
Medium	Works engineered by an affiliate/ plant (installing a new design of knockout pot for a feed to a unit)	6-9 months	2-3
Small	Minor affiliate/plant works (installing piping to bypass a control valve)	1-2 months	1

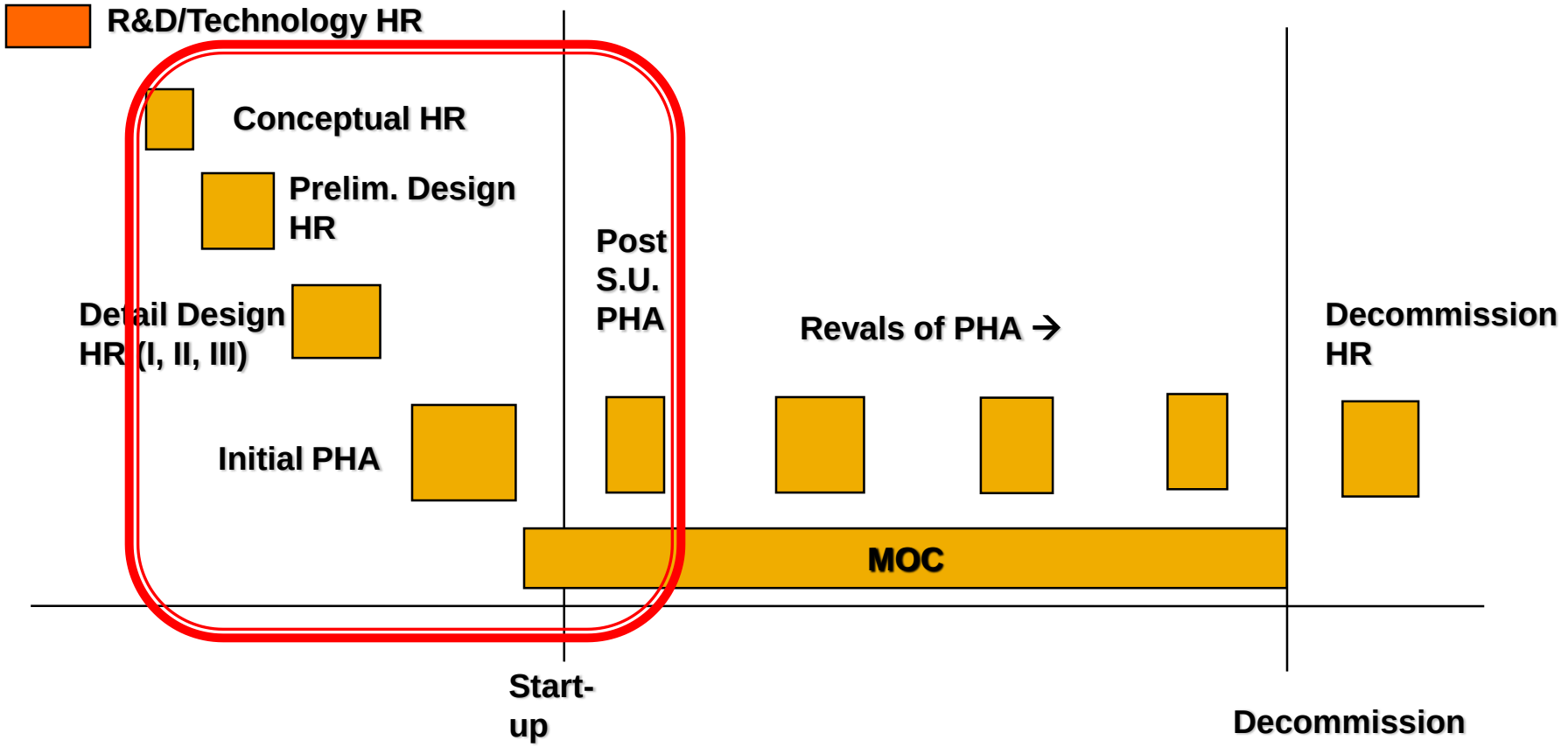
PSM Deliverables from Project –

works best if understood as same management practices required for excellent operability & reliability

ABC – Knoxville Chlorine Plant 3/25/2008



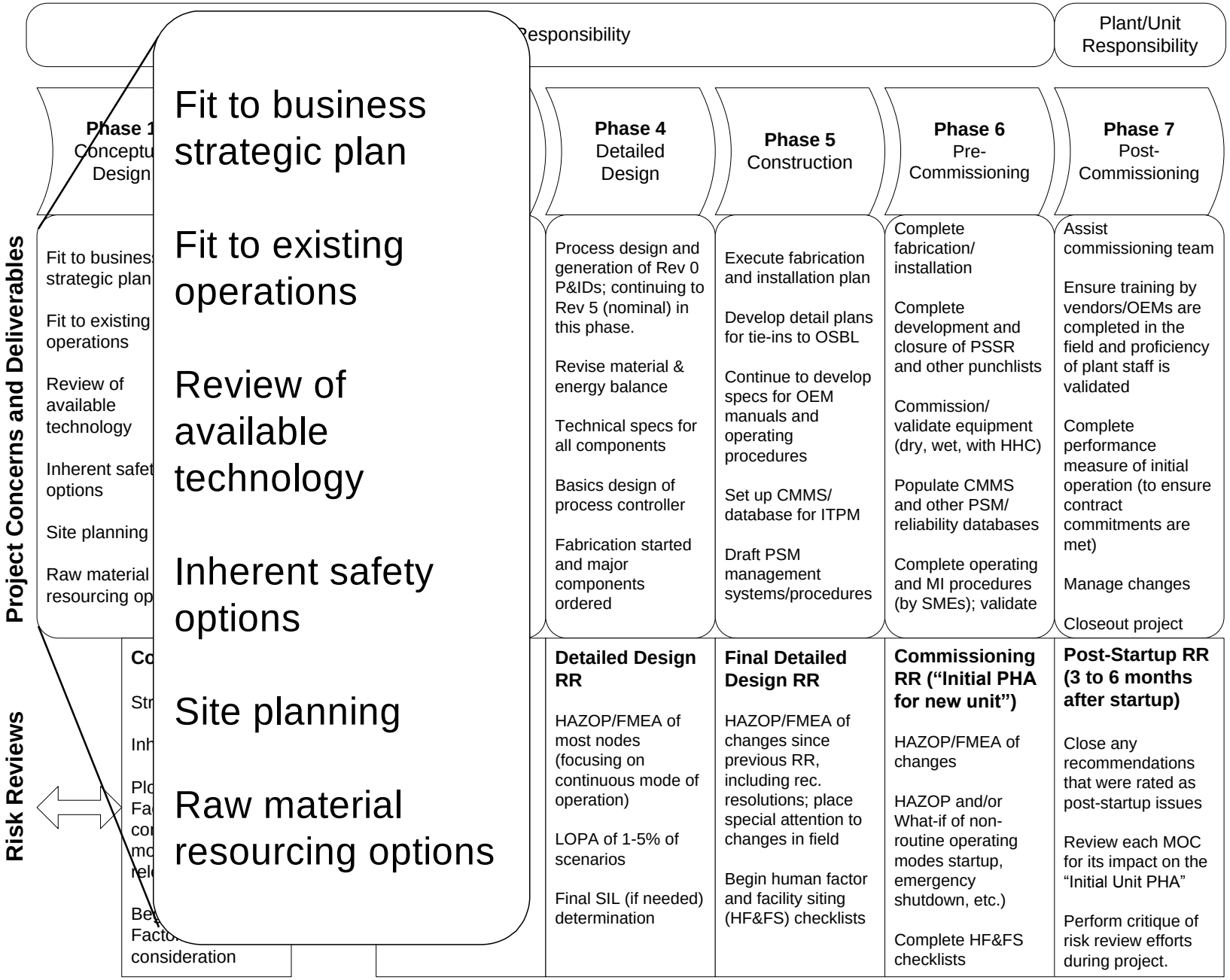
Types of Hazard/Risk Reviews in Life Cycle of a Process (each type uses one or more of the HR (PHA) methods)



Example from Process Improvement Institute, Inc., PHA Leadership Course, 2003

Project Responsibility | Plant/Unit Responsibility

	Phase 1 Conceptual Design	Phase 2 Feasibility & Detailed Specification	Phase 3 Preliminary Design	Phase 4 Detailed Design	Phase 5 Construction	Phase 6 Pre-Commissioning	Phase 7 Post-Commissioning
Project Concerns and Deliverables	Fit to business strategic plan Fit to existing operations Review of available technology Inherent safety options Site planning Raw material resourcing options	Detailed feasibility study (availability of technical staff; marketing plan) Detailed technology review and specification development Preliminary plot plan and tie-in plan +/- 40% cost estimate Preliminary schedule & milestones	Preliminary construction & operation plans Initial process flow diagrams (PFDs) Initial material and energy balances Raw material planning Utility planning Candidate vendors for major components Fire protection plan	Process design and generation of Rev 0 P&IDs; continuing to Rev 5 (nominal) in this phase. Revise material & energy balance Technical specs for all components Basics design of process controller Fabrication started and major components ordered	Execute fabrication and installation plan Develop detail plans for tie-ins to OSBL Continue to develop specs for OEM manuals and operating procedures Set up CMMS/ database for ITPM Draft PSM management systems/procedures	Complete fabrication/ installation Complete development and closure of PSSR and other punchlists Commission/ validate equipment (dry, wet, with HHC) Populate CMMS and other PSM/ reliability databases Complete operating and MI procedures (by SMEs); validate	Assist commissioning team Ensure training by vendors/OEMs are completed in the field and proficiency of plant staff is validated Complete performance measure of initial operation (to ensure contract commitments are met) Manage changes Closeout project
Risk Reviews	**Conceptual RR** Strategic plans Inherent safety Plot plan review for Facility Siting; consequence modeling for major releases Begin Human Factor consideration		**Preliminary Design RR** What-if analysis of each major unit operation HAZOP/FMEA of selected scenarios LOPA of selected scenarios & review options for inherent safety	**Detailed Design RR** HAZOP/FMEA of most nodes (focusing on continuous mode of operation) LOPA of 1-5% of scenarios Final SIL (if needed) determination	**Final Detailed Design RR** HAZOP/FMEA of changes since previous RR, including rec. resolutions; place special attention to changes in field Begin human factor and facility siting (HF&FS) checklists	**Commissioning RR ("Initial PHA for new unit")** HAZOP/FMEA of changes HAZOP and/or What-if of non-routine operating modes startup, emergency shutdown, etc.) Complete HF&FS checklists	**Post-Startup RR (3 to 6 months after startup)** Close any recommendations that were rated as post-startup issues Review each MOC for its impact on the "Initial Unit PHA" Perform critique of risk review efforts during project.


Responsibility
Plant/Unit Responsibility
Phase 1 Conceptu Design
Phase 4 Detailed Design
Phase 5 Construction
Phase 6 Pre-Commissioning
Phase 7 Post-Commissioning
Project Concerns and Deliverables
Fit to busines strategic plan
Fit to existing operations
Review of available technology
Inherent safet options
Site planning
Raw material resourcing op
Process design and generation of Rev 0 P&IDs; continuing to Rev 5 (nominal) in this phase.
Revise material & energy balance
Technical specs for all components
Basics design of process controller
Fabrication started and major components ordered
Execute fabrication and installation plan
Develop detail plans for tie-ins to OSBL
Continue to develop specs for OEM manuals and operating procedures
Set up CMMS/ database for ITPM
Draft PSM management systems/procedures
Complete fabrication/ installation
Complete development and closure of PSSR and other punchlists
Commission/ validate equipment (dry, wet, with HHC)
Populate CMMS and other PSM/ reliability databases
Complete operating and MI procedures (by SMEs); validate
Assist commissioning team
Ensure training by vendors/OEMs are completed in the field and proficiency of plant staff is validated
Complete performance measure of initial operation (to ensure contract commitments are met)
Manage changes
Closeout project
Risk Reviews
Co
Str
Inh
Plc
Fa
co
mo
rel
Be
Facto
consideration
Detailed Design RR
HAZOP/FMEA of most nodes (focusing on continuous mode of operation)
LOPA of 1-5% of scenarios
Final SIL (if needed) determination
Final Detailed Design RR
HAZOP/FMEA of changes since previous RR, including rec. resolutions; place special attention to changes in field
Begin human factor and facility siting (HF&FS) checklists
Commissioning RR (“Initial PHA for new unit”)
HAZOP/FMEA of changes
HAZOP and/or What-if of non-routine operating modes startup, emergency shutdown, etc.)
Complete HF&FS checklists
Post-Startup RR (3 to 6 months after startup)
Close any recommendations that were rated as post-startup issues
Review each MOC for its impact on the “Initial Unit PHA”
Perform critique of risk review efforts during project.
Fit to business strategic plan
Fit to existing operations
Review of available technology
Inherent safety options
Site planning
Raw material resourcing options

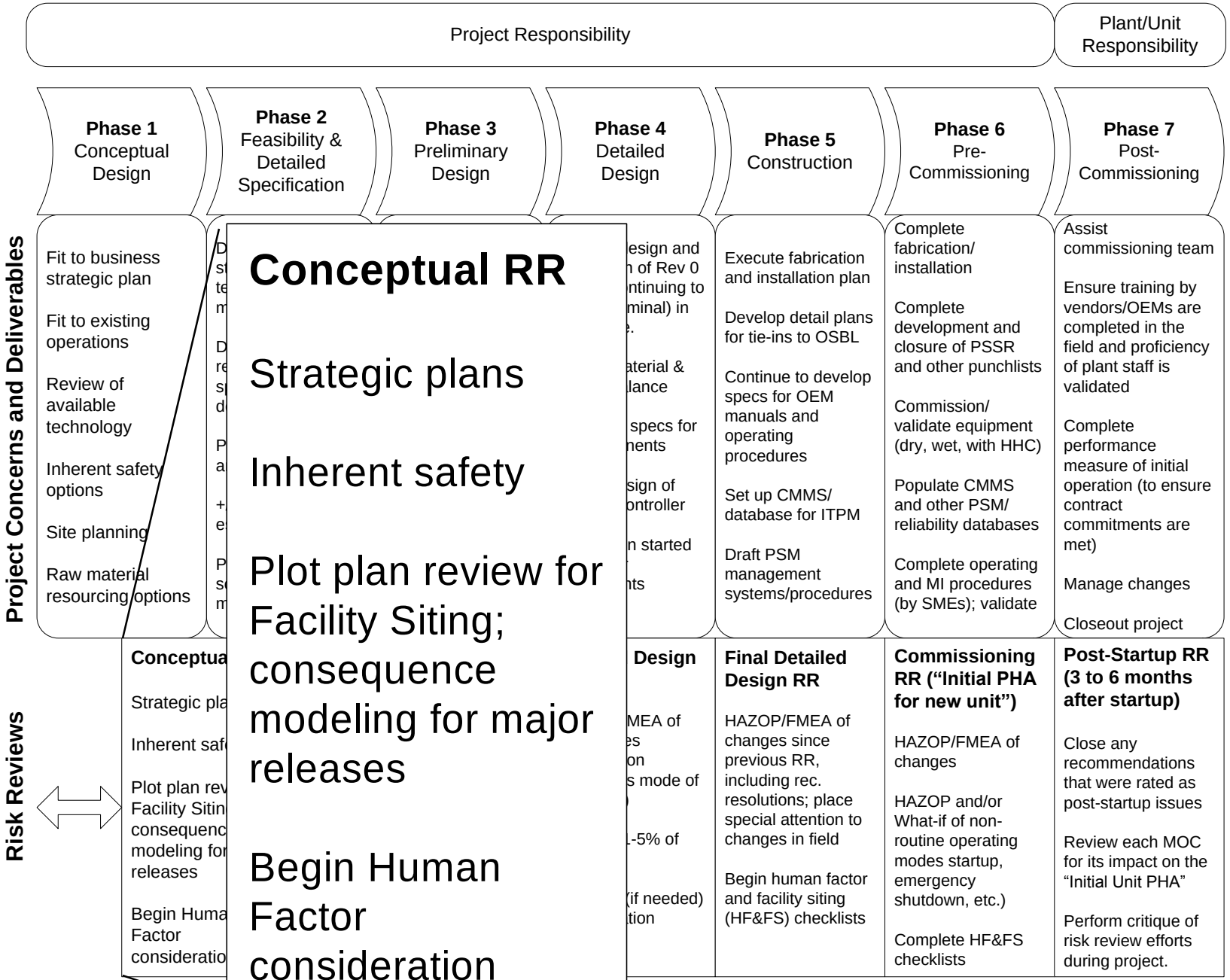
Conceptual Design Phase

Key Concern	Ways to Address/Evaluate Key Concern during Design and Risk Reviews
Inherently safe/reliability process selection	▪ Evaluate low waste chemistries ▪ Evaluate low inventory ▪ Evaluate use of non-hazardous solvents and reagents ▪ Evaluate low energy reac
Plot Location Relative to Other Units	▪ Process opportunities ▪ Operating logistics ▪ Distance from con ▪ Backup contingen ▪ Knock-on effects f modeling is necess ▪ Begin Facility Siti
Size of Plot Areas – based on preliminary process designs	▪ Access to utilities ▪ Cost of real estate, ▪ Elevation consider
Precise Spacing Between Unit Boundaries – distances between battery limits or between nearby units	▪ Insurance and Indu ▪ Knock-on effect to ▪ Business interrupti
Inner Unit Layout	▪ Ease of Access (be maintainability ▪ Constructability ar for construction an ▪ Equipment decking a ladders to take routine pr
Fire Protection Review	▪ Emergency access routes; Fire fighting or toxic rescue capability ▪ Placement of detectors ▪ Strategy to protect neighbors from your releases ▪ Construction of control rooms to protect “stay-behinds”

Example of more detail in the paper

PSM Deliverables – Phase 1 & 2: Conceptual Design

- **Process safety information,** including chemical hazards, reactivity, hazards of inadvertent mixing, inventories, applicable codes & standards
- **Baseline info for future PHA**
- **Baseline info for future MI**
- **Begin inherently safer consideration**
- **Begin leadership**
- **Begin employee participation**


Project Responsibility
Plant/Unit Responsibility
Phase 1 Conceptual Design
Phase 2 Feasibility & Detailed Specification
Phase 3 Preliminary Design
Phase 4 Detailed Design
Phase 5 Construction
Phase 6 Pre-Commissioning
Phase 7 Post-Commissioning
Project Concerns and Deliverables
Fit to business strategic plan
Fit to existing operations
Review of available technology
Inherent safety options
Site planning
Raw material resourcing options
Execute fabrication and installation plan
Develop detail plans for tie-ins to OSBL
Continue to develop specs for OEM manuals and operating procedures
Set up CMMS/ database for ITPM
Draft PSM management systems/procedures
Complete fabrication/ installation
Complete development and closure of PSSR and other punchlists
Commission/ validate equipment (dry, wet, with HHC)
Populate CMMS and other PSM/ reliability databases
Complete operating and MI procedures (by SMEs); validate
Assist commissioning team
Ensure training by vendors/OEMs are completed in the field and proficiency of plant staff is validated
Complete performance measure of initial operation (to ensure contract commitments are met)
Manage changes
Closeout project
Risk Reviews
Final Detailed Design RR
HAZOP/FMEA of changes since previous RR, including rec. resolutions; place special attention to changes in field
Begin human factor and facility siting (HF&FS) checklists
Commissioning RR (“Initial PHA for new unit”)
HAZOP/FMEA of changes
HAZOP and/or What-if of non-routine operating modes startup, emergency shutdown, etc.)
Complete HF&FS checklists
Post-Startup RR (3 to 6 months after startup)
Close any recommendations that were rated as post-startup issues
Review each MOC for its impact on the “Initial Unit PHA”
Perform critique of risk review efforts during project.
Conceptual RR
Strategic plans
Inherent safety
Plot plan review for Facility Siting; consequence modeling for major releases
Begin Human Factor consideration

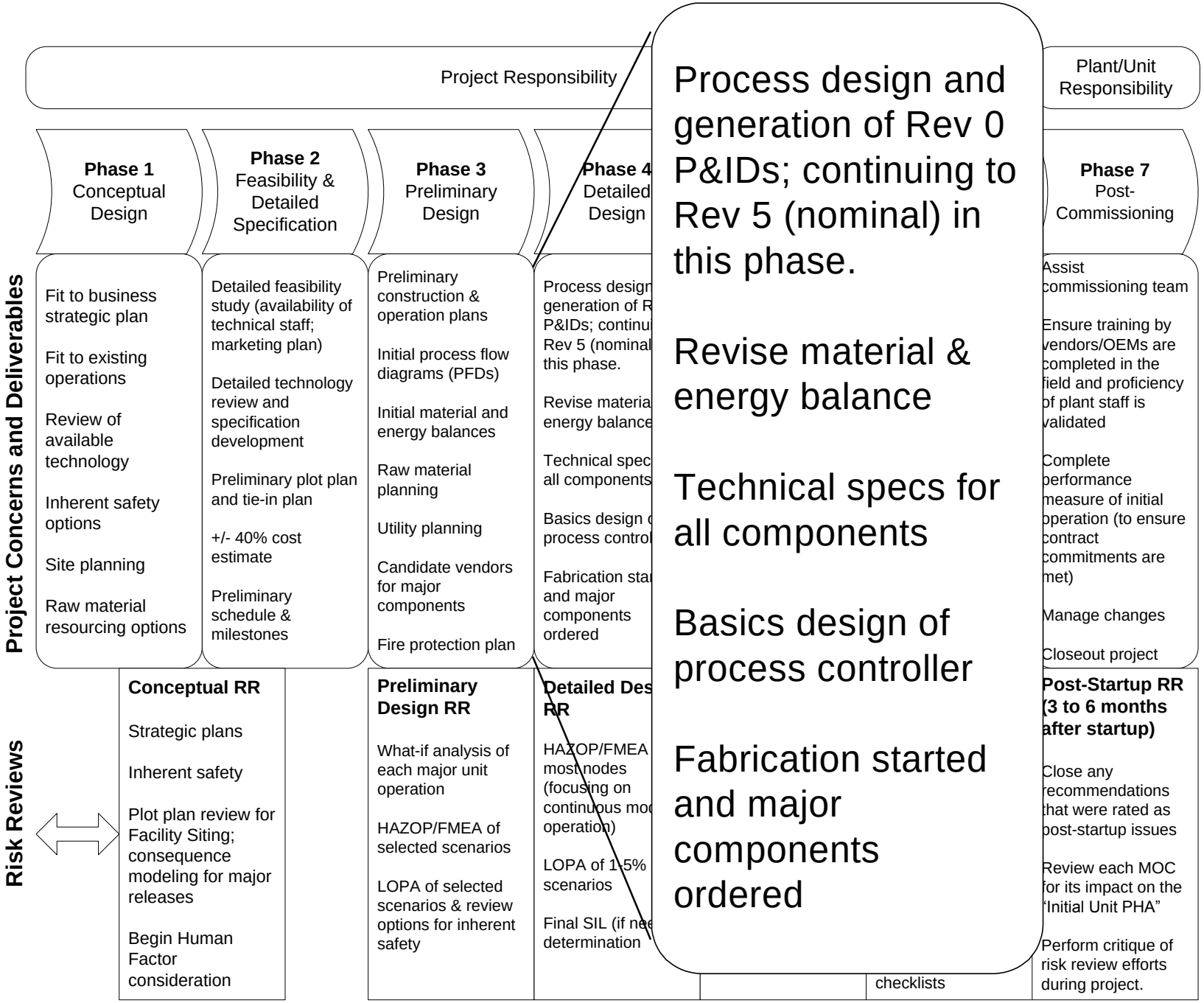
Keys to Excellent Risk Reviews in Conceptual & Preliminary Phases

- On the risk review team, include:
  - senior operator from an existing or very similar unit
  - senior process engineer from an existing or similar unit
  - even if these persons must be contracted or must travel a great distance to attend the Risk Review
- Exclude project management from the PHA team meetings (they will have a chance later to accept/reject recommendations)
- Allow contingency in budget and schedule for possible changes

Keys to Excellent Risk Reviews in Conceptual & Preliminary Phases (cont.)

- **NEVER let the contractor/vendor manage the risk review or provide the risk review leader. The leader should be:**
  - Independent of the project team
  - Independent of contractors/vendors
  - Independent of the Unit/Process/Plant that the major project is related to
  - Fully capable PHA team leaders/facilitators (well trained and practiced in the HAZOP, FMEA, and What-If methods)

- **Force the consideration of inherently safer & more reliable alternatives**

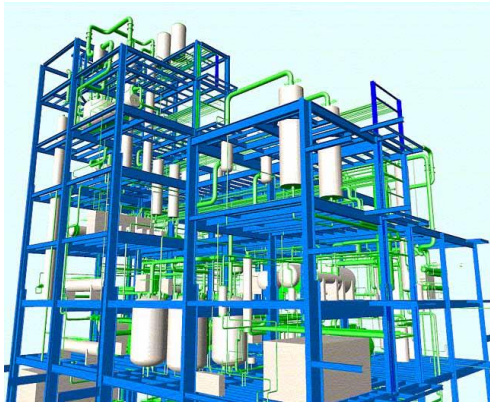

Project Responsibility
Plant/Unit Responsibility
Phase 1 Conceptual Design
Phase 2 Feasibility & Detailed Specification
Phase 3 Preliminary Design
Phase 4 Detailed Design
Phase 7 Post-Commissioning
Project Concerns and Deliverables
Fit to business strategic plan
Fit to existing operations
Review of available technology
Inherent safety options
Site planning
Raw material resourcing options
Detailed feasibility study (availability of technical staff; marketing plan)
Detailed technology review and specification development
Preliminary plot plan and tie-in plan
+/- 40% cost estimate
Preliminary schedule & milestones
Preliminary construction & operation plans
Initial process flow diagrams (PFDs)
Initial material and energy balances
Raw material planning
Utility planning
Candidate vendors for major components
Fire protection plan
Process design generation of R P&IDs; continu Rev 5 (nominal this phase.
Revise materia energy balance
Technical spec all components
Basics design c process control
Fabrication sta and major components ordered
Assist commissioning team
Ensure training by vendors/OEMs are completed in the field and proficiency of plant staff is validated
Complete performance measure of initial operation (to ensure contract commitments are met)
Manage changes
Closeout project
Risk Reviews
Conceptual RR
Strategic plans
Inherent safety
Plot plan review for Facility Siting; consequence modeling for major releases
Begin Human Factor consideration
Preliminary Design RR
What-if analysis of each major unit operation
HAZOP/FMEA of selected scenarios
LOPA of selected scenarios & review options for inherent safety
Detailed Des RR
HAZOP/FMEA most nodes (focusing on continuous mo operation)
LOPA of 1-5% scenarios
Final SIL (if ne determination
checklists
Post-Startup RR (3 to 6 months after startup)
Close any recommendations that were rated as post-startup issues
Review each MOC for its impact on the "Initial Unit PHA"
Perform critique of risk review efforts during project.
Process design and generation of Rev 0 P&IDs; continuing to Rev 5 (nominal) in this phase.
Revise material & energy balance
Technical specs for all components
Basics design of process controller
Fabrication started and major components ordered

PSM Deliverables – Phase 3
Preliminary Design

- **Process safety information,** including codes & standards, PFDs, thermal/kinetic chemistry information, material & energy balances, and materials of construction
- **Facility siting basis set**
- **Begin emergency response planning**
- **Baseline info for future PHA**
- **Baseline info for future MI**
- **Continue employee participation**

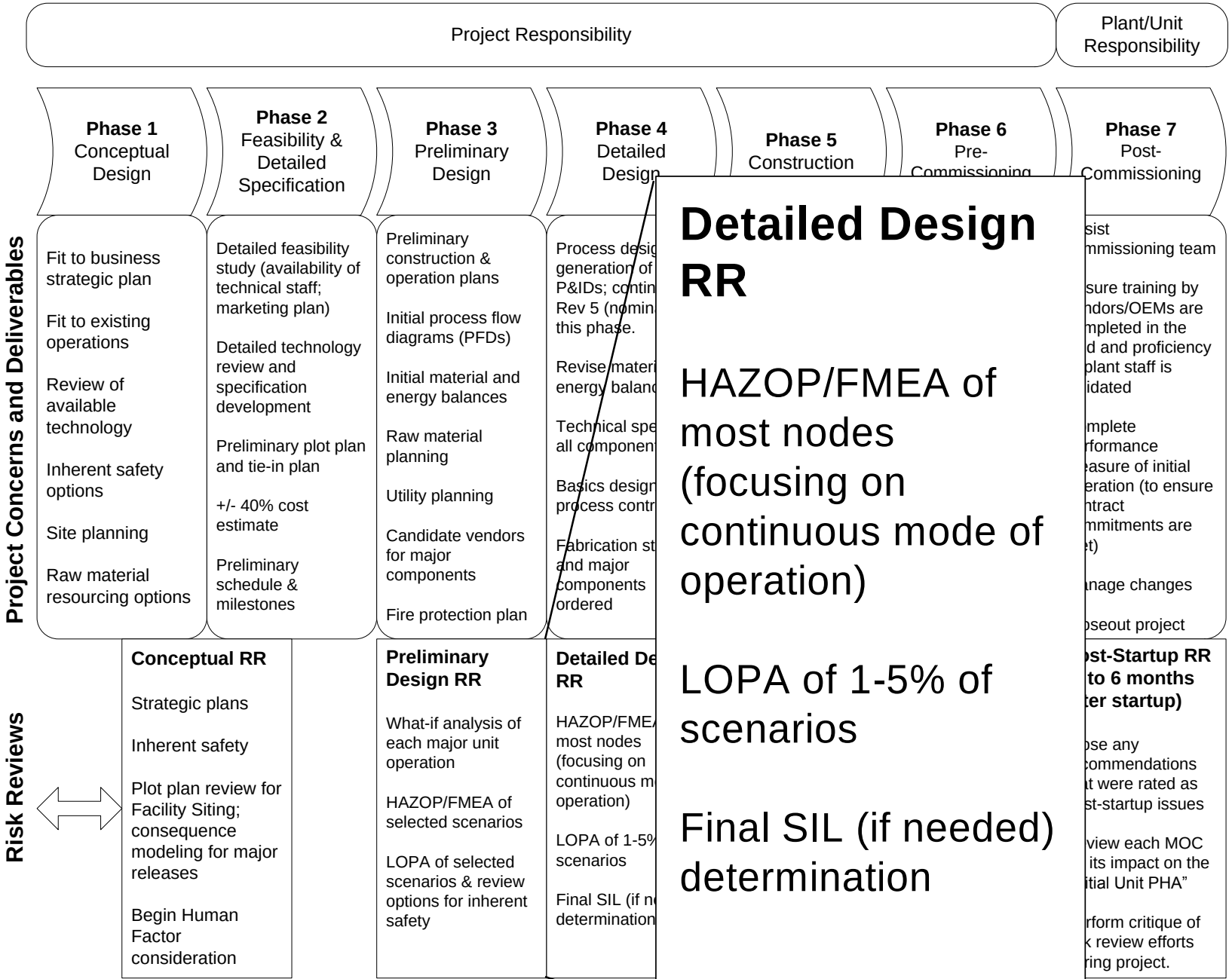
PSM Deliverables – Phase 4
Detailed Design

- Process safety information, including P&IDs, revised materials of construction, safety interlocks and controls, equipment design basis and some final equipment details, 3D drawings
- Multiple layers of protection
- Detailed info for future PHA
- Detailed info for future MI
- Begin detailed emergency response plans
- Continue employee participation



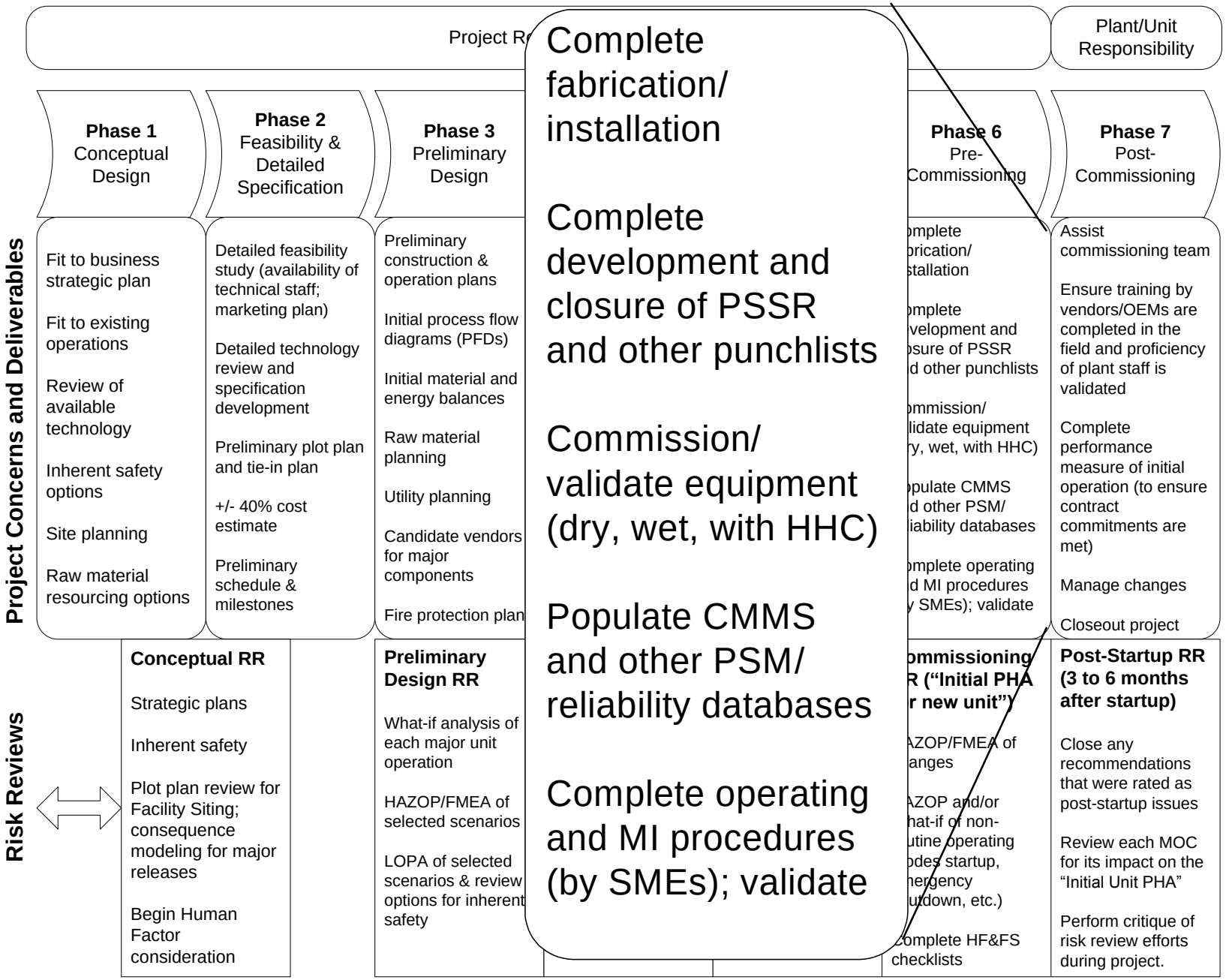
PSM Deliverables – Phase 4
Detailed Design (continued)

- **Maximize inherently safer design in the selected process, such as:**
  - **Lower feed pump pressures to make hydraulic overpressure impossible**
  - **Optimize reactor conditions and recycle loops to minimize waste**
  - **Design manual charge stations at ergonomic work height**
  - **Design tanks to withstand maximum possible pressure**


Project Responsibility
Plant/Unit Responsibility
Phase 1 Conceptual Design
Phase 2 Feasibility & Detailed Specification
Phase 3 Preliminary Design
Phase 4 Detailed Design
Phase 5 Construction
Phase 6 Pre-Commissioning
Phase 7 Post-Commissioning
Project Concerns and Deliverables
Fit to business strategic plan
Fit to existing operations
Review of available technology
Inherent safety options
Site planning
Raw material resourcing options
Detailed feasibility study (availability of technical staff; marketing plan)
Detailed technology review and specification development
Preliminary plot plan and tie-in plan
+/- 40% cost estimate
Preliminary schedule & milestones
Preliminary construction & operation plans
Initial process flow diagrams (PFDs)
Initial material and energy balances
Raw material planning
Utility planning
Candidate vendors for major components
Fire protection plan
Process desig
generation of
P&IDs; contin
Rev 5 (nomin
this phase.
Revise materi
energy balanc
Technical spe
all componen
Basics design
process contr
Fabrication st
and major
components
ordered
sist
mmissioning team
sure training by
ndors/OEMs are
mpleted in the
d and proficiency
plant staff is
idated
mplete
rformance
easure of initial
eration (to ensure
ntract
mmitments are
t)
nage changes
oseout project
Risk Reviews
Conceptual RR
Strategic plans
Inherent safety
Plot plan review for Facility Siting; consequence modeling for major releases
Begin Human Factor consideration
Preliminary Design RR
What-if analysis of each major unit operation
HAZOP/FMEA of selected scenarios
LOPA of selected scenarios & review options for inherent safety
Detailed De
RR
HAZOP/FME
most nodes
(focusing on
continuous m
operation)
LOPA of 1-5%
scenarios
Final SIL (if n
determination
st-Startup RR
to 6 months
er startup)
se any
commendations
t were rated as
st-startup issues
view each MOC
its impact on the
itial Unit PHA”
rform critique of
k review efforts
ring project.
Detailed Design RR
HAZOP/FMEA of most nodes (focusing on continuous mode of operation)
LOPA of 1-5% of scenarios
Final SIL (if needed) determination

Keys to Performing Excellent Risk Reviews in Detailed Engineering Phase

- Continue to have your most senior operators and process engineers on the Risk Review team
- Catch design problems before they create operational traps, by applying equal focus to hazards and operability/quality issues

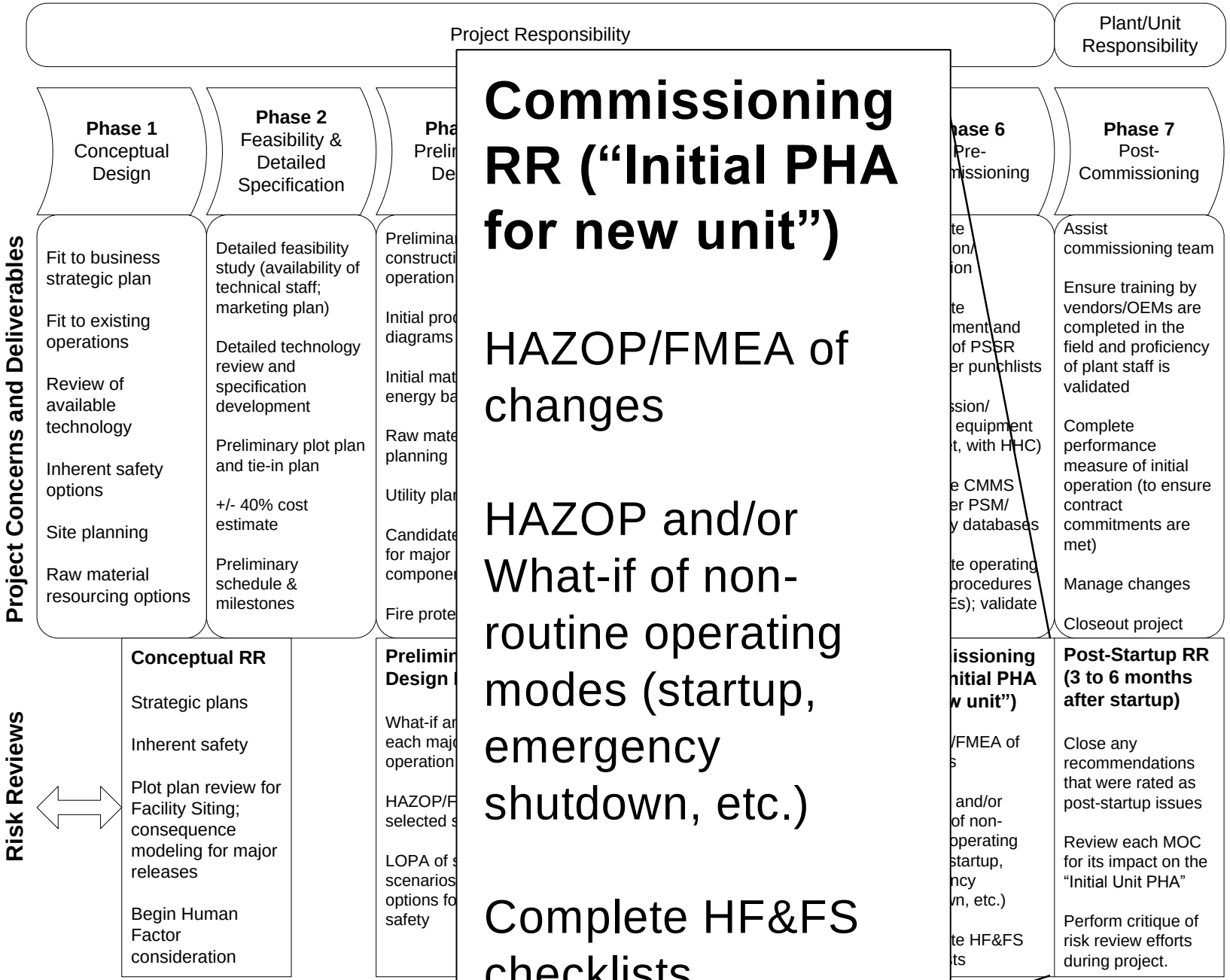

Project R
Plant/Unit Responsibility
Phase 1 Conceptual Design
Phase 2 Feasibility & Detailed Specification
Phase 3 Preliminary Design
Phase 6 Pre-Commissioning
Phase 7 Post-Commissioning
Project Concerns and Deliverables
Fit to business strategic plan
Fit to existing operations
Review of available technology
Inherent safety options
Site planning
Raw material resourcing options
Detailed feasibility study (availability of technical staff; marketing plan)
Detailed technology review and specification development
Preliminary plot plan and tie-in plan
+/- 40% cost estimate
Preliminary schedule & milestones
Preliminary construction & operation plans
Initial process flow diagrams (PFDs)
Initial material and energy balances
Raw material planning
Utility planning
Candidate vendors for major components
Fire protection plan
mplete
brication/
stallation
mplete
velopment and
sure of PSSR
d other punchlists
mmission/
lidate equipment
y, wet, with HHC)
pulate CMMS
d other PSM/
liability databases
mplete operating
d MI procedures
y SMEs); validate
Assist commissioning team
Ensure training by vendors/OEMs are completed in the field and proficiency of plant staff is validated
Complete performance measure of initial operation (to ensure contract commitments are met)
Manage changes
Closeout project
Risk Reviews
Conceptual RR
Strategic plans
Inherent safety
Plot plan review for Facility Siting; consequence modeling for major releases
Begin Human Factor consideration
Preliminary Design RR
What-if analysis of each major unit operation
HAZOP/FMEA of selected scenarios
LOPA of selected scenarios & review options for inherent safety
ommissioning
R ("Initial PHA
r new unit")
AZOP/FMEA of
anges
AZOP and/or
hat-if of non-
utine operating
odes startup,
nergency
utdown, etc.)
omplete HF&FS
checklists
Post-Startup RR (3 to 6 months after startup)
Close any recommendations that were rated as post-startup issues
Review each MOC for its impact on the "Initial Unit PHA"
Perform critique of risk review efforts during project.
Complete fabrication/ installation
Complete development and closure of PSSR and other punchlists
Commission/ validate equipment (dry, wet, with HHC)
Populate CMMS and other PSM/ reliability databases
Complete operating and MI procedures (by SMEs); validate

PSM Deliverables – Phase 5
Final Design

- Process safety information (revisions)
- Multiple layers of protection (revisions)
- Revisions/updates building to initial PHA
- Revised data for MI, including development of inspection, test, PM plans and populating databases
- Begin detailed consideration of human factors
- Data for developing operating and maintenance procedures
- Continue employee participation

PSM Deliverables – Phase 6 Commissioning

- Process safety information (revisions)
- Complete the initial PHA
- Revise MI plans, procedures, and database
- Complete detailed consideration of human factors
- Complete development of emergency response plans, operating procedures, and initial training
- Develop remaining elements of PSM, including MOC procedures and incident reporting and investigation system
- Conduct initial PSSR


Project Responsibility
Plant/Unit Responsibility
Phase 1 Conceptual Design
Phase 2 Feasibility & Detailed Specification
Phase 7 Post-Commissioning
Project Concerns and Deliverables
Fit to business strategic plan
Fit to existing operations
Review of available technology
Inherent safety options
Site planning
Raw material resourcing options
Detailed feasibility study (availability of technical staff; marketing plan)
Detailed technology review and specification development
Preliminary plot plan and tie-in plan
+/- 40% cost estimate
Preliminary schedule & milestones
Assist commissioning team
Ensure training by vendors/OEMs are completed in the field and proficiency of plant staff is validated
Complete performance measure of initial operation (to ensure contract commitments are met)
Manage changes
Closeout project
Risk Reviews
Conceptual RR
Strategic plans
Inherent safety
Plot plan review for Facility Siting; consequence modeling for major releases
Begin Human Factor consideration
Post-Startup RR (3 to 6 months after startup)
Close any recommendations that were rated as post-startup issues
Review each MOC for its impact on the "Initial Unit PHA"
Perform critique of risk review efforts during project.
Commissioning RR ("Initial PHA for new unit")
HAZOP/FMEA of changes
HAZOP and/or What-if of non-routine operating modes (startup, emergency shutdown, etc.)
Complete HF&FS checklists

Key to Performing Excellent Risk Reviews in Commissioning Phase

- Continue to have your most senior operators and process engineers on the Risk Review team, BUT add a second operator to the team
- Perform Risk Review (HAZOP/What-If) of start-up, shutdown, emergency shutdown, and on-line maintenance procedures ← This is the most frequently observed weakness in the project risk review cycle *(see Chapter 9.1, Hazard Evaluation Procedures, 3rd edition, CCPS/AIChE 2008)*

Project is Complete, including:

- Mechanically complete and verified to be fit for duty
- Staff ready to operate and maintain equipment

- Initial PHA is complete (the risk review at each project phase has built sequentially to this deliverable)
- All PSM high level systems & implementation level documents, activities, and support systems are in place

Example: New Ethylene Plant

- **Size: 250 nodes of equipment (nodes are vessels, columns, heaters, lines/exchanger circuits, etc.) plus all operating procedures (done in time for last project hazard review phase)**

	HAZARD REVIEW ESTIMATES					
	Conceptual	**Preliminary**	**Detailed**	**Construction**	**Pre-Startup**	**Total**
Meeting Time	1 week	3 weeks	5 weeks	3 weeks	3 weeks	**15 wks**
Team Size	8	8	8	6	6	
Staff Hours Total	164	1152	2120	864	984	**5284**
Cumulative Schedule	2 months	6 months	14 months	18 months	22 months	**24-30 mon**
Focus	Plot plans, process options, tie-in options (WI and some modeling)	Cursory HAZOP, FMEA, and WI	Rigorous HAZOP, FMEA, and WI; start checklists	Changes since previous; finish checklists	SOP Hazard Review & Changes since previous	

Example: New Ore Conveying

- **Size: 10 nodes of equipment (nodes are conveyors, screen, crushing, storage, dedusting, etc .) plus all operating procedures (done in time for last project hazard review phase)**

	HAZARD REVIEW ESTIMATES		
	Detailed	**Pre-Started**	**Total**
Meeting Time	2 days	2 days	**4 days**
Team Size	10	10	
Staff Hours Total	218	202	**419**
Cumulative Schedule	3 months	9 months	**10-11 mon**
Focus	Rigorous WI, some FMEA; start checklists	SOP Hazard Review & Changes since previous	

Conclusions – Keys to Success

- Effective company leadership and effective project management, where the **primary goal** is an efficient operating unit (long-term process reliability and safety) – ***where this primary goal outweighs the secondary goals of bringing in a project on schedule and on budget***
- Including experienced operators and experienced process engineers on the risk review teams, **from the very start of the project**
- Developing PSM elements **at each project phase** to better ensure the final process is efficient and safe to operate

Conclusions – Keys to Success (continued)

- Having subject matter experts develop procedures (operating, maintenance, and lab procedures) and performing the risk review of each of these procedures to ensure there are sufficient safeguards to protect the new process & people when the imperfect humans do not follow the procedures perfectly (1/100 error rate is typical best case)
- Developing trouble-shooting guides from PHA
- Delivering a project that allows sustainable control of human error

Thank you

Questions & Comments are Welcome

adakheel@piii.com

Stop by PII booth