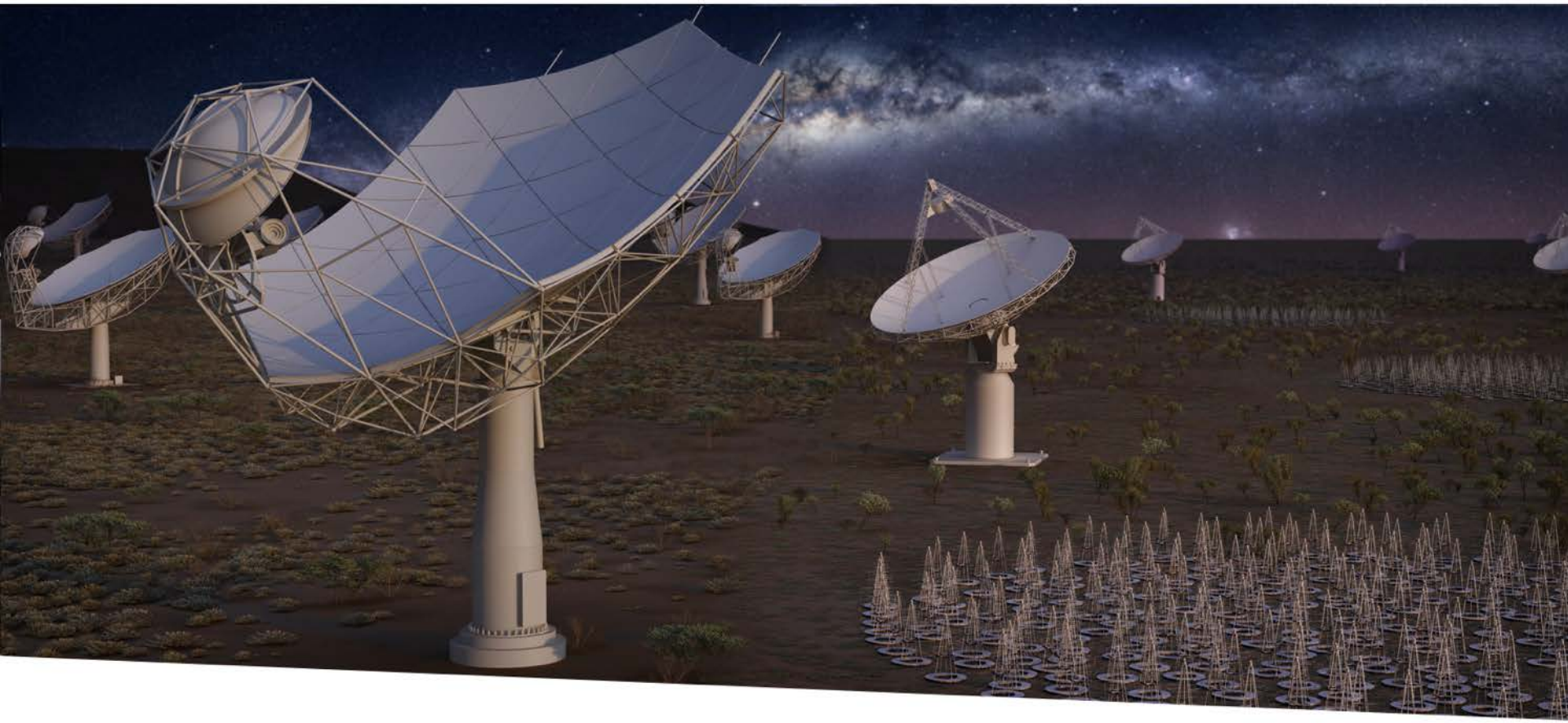
Early Production Arrays

Construction Proposal Overview, Objectives, Risks



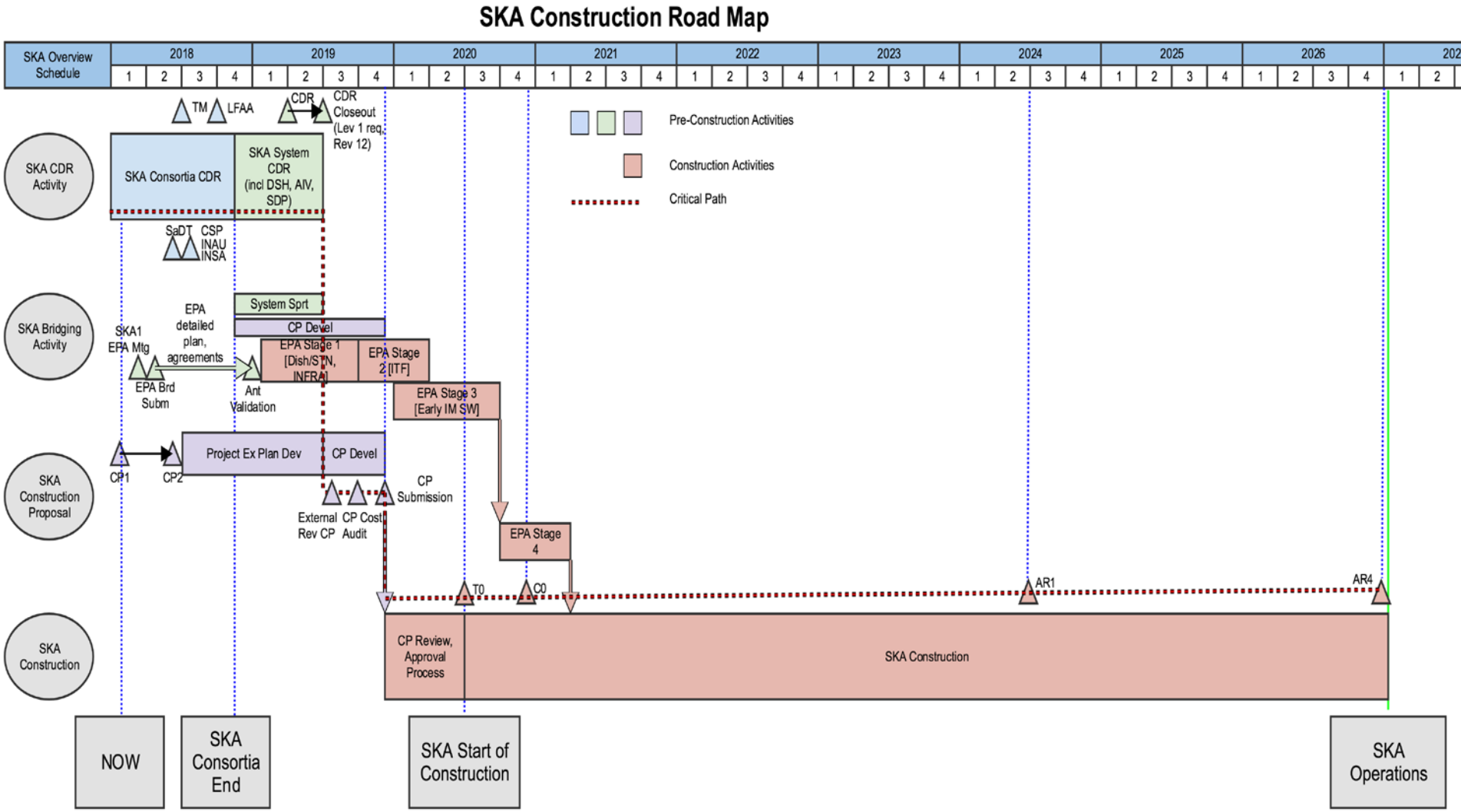
SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

J. McMullin

07 Mar 2018

High Level Road Map



Construction Proposal Development

- Project Execution Plan framework
  - matches PMI, ISO 21500 systems (next slide)
  - emphasis on integration
  - emphasis on control, predictability, transparency
- Concept is to finalize our organization and processes for executing construction (PEP)
  - Defend this through external review and cost audit
  - Develop high level summary Construction Proposal
    - Include full PEP, External review results, Cost audit results
- Submit to IGO

PEP vs PMI vs ISO 21500

	ISO 21500	PMBOK	PEP
Subject Area	Process	Process	Process
Integration	4.3.2 Develop Project Charter	4.1 Develop Project Charter	1.1 Scientific Objectives. 1.2 Scientific Requirements. 1.3 Facility Infrastructure. 1.4 Scientific & Broader Societal Impacts
	4.3.3 Develop Project Plans	4.2 Develop Project Management Plan 5.1 Plan Scope Management 6.1 Plan Schedule Management 7.1 Plan Cost Management 9.1 Plan Human Resource Management 11.1 Plan Risk Management Plan 12.2 Stakeholder Management	4.4 Scope Management Plan and Scope Contingency 4.9 Baseline Schedule Estimating Plan and Integrated Schedule 4.5 Cost Estimating Plan, Cost Reports, and Baseline Budget. 6.1 Risk Management Plan 2.2 External Organization and Communication
	4.3.4 Direct Project Work	4.3 Direct and Manage Project Work	10.1 Project Management Control Plan
	4.3.5 Control Project Work	4.4 Monitor and Control Project Work	10.1 Project Management Control Plan
	4.3.6 Control changes	4.5 Perform Integrated Change Control	10.1 Project Management Control Plan. 8.1 Configuration Control Plan. 8.3 Document Control Plan
	4.3.7 Close project phase or project	4.6 Close Project or Project Phase	16.1 Project Close out
	4.3.8 Collect lessons learned		
			10.2 Earned Value Management System
Stakeholders	4.3.9 Identify Stakeholders	13.1 Identify Stakeholders	2.2 External Organization and Communication 2.3 Partnerships 2.5 Community Relations and Outreach
	4.3.10 Manage Stakeholders	13.3 Manage Stakeholder Engagement 13.4 Control Stakeholder Engagement	2.2 External Organization and Communication
Scope	4.3.11 Define scope	5.2 Collect Requirements. 5.3 Define Sscope	4.1 Summary of Total Project Definition
	4.3.12 Create WBS	5.4 Create WBS	4.2 Work Breakdown Structure (WBS)
			4.3 WBS Dictionary
	4.3.13 Define Activities	6.2 Define Activities	
	4.3.14 Control scope	5.5 Validate Scope 5.6 Control scope	8.2 Change Control Plan. 10.1 Project Management Control Plan
			11. Site and Environment. 12. Cyber Infrastructure 13. Environmental, Safety and Health
Resources	4.3.15 Establish project team	9.2 Acquire project team	5.2 Hiring and Staff transition plan
	4.3.16 Estimate resources	6.4 Estimate Activity Resources	5.1 Staffing plan
	4.3.17 Define project organization	9.1 Plan Human Resource Management	2.1 Internal Governance & Organization. 2.4 Roles and Responsibilities
	4.3.18 Develop project team	9.3 Develop project team	5.2 Hiring and Staff transition plan
	4.3.19 Central resources	-	-
	4.3.20 Manage project team	9.4 Manage project team	10.1 Project Management Control Plan
Time	4.3.21 Sequence activities	6.3 Sequence Activities	4.9 Baseline Schedule Estimating Plan and Integrated Schedule
	4.3.22 Estimate activity durations	6.5 Estimate Activity Durations	4.9 Baseline Schedule Estimating Plan and Integrated Schedule
	4.3.23 Develop schedule	6.6 Develop Schedule	4.9 Baseline Schedule Estimating Plan and Integrated Schedule
	4.3.24 Control schedule	6.7 Control Schedule	10.1 Project Management Control Plan
			4.10 Schedule Contingency
Cost	4.3.25 Estimate costs	7.2 Estimate Costs	4.5 Cost Estimating Plan, Cost Reports, and Baseline Budget
	4.3.26 Develop budget	7.3 Determine Budget	4.7 Cost Book, Cost Model Data Set, and Basis of Estimate
	4.3.27 Control costs	7.4 Control Costs	10.1 Project Management Control Plan
			4.6 Budget Contingency 4.8 Funding Profile
Risk	4.3.28 Identify risks	11.2 Identify Risks	6.1 Risk Management Plan
	4.3.29 Assess risks	11.3 Perform Qualitative Risk Analysis. 11.4 Perform Quantitative Risk Analysis	6.1 Risk Management Plan. 6.2 Risk Register
	4.3.30 Treat risks	11.5 Plan Risk Responses	6.2 Risk Register
	4.3.31 Control risks	11.6 Control Risks	6.2 Risk Register 6.3 Contingency Management Plan
Quality	4.3.32 Plan quality	8.1 Plan Quality Management	7.4 QA/QC Plans
	4.3.33 Perform quality assurance	8.2 Peform Quality Assurance	7.4 QA/QC Plans
	4.3.34 Perform quality control	8.3 Control Quality	7.4 QA/QC Plans
			7.1 Systems Engineering Plan
			7.2 Systems Engineering Requirements
			7.3 Interface Management Plan
			7.5 Operational Concepts
			15.1 Integration and Commissioning Plan
			15.2 Acceptance and Operational Readiness Plan
Procurement	4.3.35 Plan procurements	12.1 Plan Procurement	9.1 Acquisitions Plans
	4.3.36 Select suppliers	12.2 Conduct Procurement	9.2 Acquisition Approval Process
	4.3.37 Administer contracts	12.3 Control Procurement	10.3 Financial and Business Controls
Communication	4.3.38 Plan communications	10.1 Plan Communications	14.1 Reviews and Reporting
	4.3.39 Distribute information	10.2 Manage Communications	14.1 Reviews and Reporting
	4.3.40 Manage communications	10.3 Control Communications	14.1 Reviews and Reporting

Construction Readiness

Organizational Readiness

- Business Systems
  - Contracting
  - Accounting (invoicing, actuals reconciliation, etc)
  - Subset needed for EPA
  - Human Resources
    - Hiring capability; training
- Project Management Control System utilities
  - Integrated Project Schedule
  - Earned Value Management System
  - Contract Performance Reporting

CDR Activity – Updates

Element	RRN Submission	CDR Submission	CDR Meeting
SaDT & SAT	17 January 2018	28 February 2018	15-18 May 2018
TM	29 January 2018	28 February 2018	17-20 Apr
CSP	05 March 2018 - PSS Element CDR - PST Element CDR	16 April 2018	29 May – 01 June 2018
INAU	19 March 2018	30 April 2018	27-29 June 2018
INSA	19 March 2018	30 April 2018	2-4 July 2018
LFAA	30 March 2018	11 May 2018	16-17 July 2018
System CDR (incl. AIV) close	See Roadmap	See Roadmap	30 March 2019
SDP	17 September 2018	31 October 2018	TBD
DSH	17 September 2018	30 November 2018 (Not confirmed)	07 January 2018 (Not confirmed)

Green: Successful phase

Red: Potential schedule change

Blue: Updated from last report

Bridging

- There is a period, currently estimated at ~18 months, between end of CDR and T_0; the start of construction.
- Consortia funding will, generally, cease ~end 2018
- It is critical that we maintain momentum in the project, both inside and outside the SKA Office.
- There is work to be done:
  - Finish incomplete work from design teams
  - Address gaps realised through System CDR
  - Software workflow will continue in Agile fashion
  - Preparatory work for Construction Phase
    - Work Package Documentation
    - Definition of Deployment Baseline
    - Changes due to CDR outcome
    - Preparation of construction proposal
- All will require resources from Office **AND** resources from consortia members.

Activity	Institute(s) (not consortia)	FTE estimate (1 FTE = 1 person for 1 year) (excludes SKAO staff)	Name of key Individual/s	Non-labour cost estimate (Euros)	Proposed funding source	Category	Risk Mitigated
TT MID follow-up: RFI Use Cases (RT12) - RFI use cases for use in system modelling and verification.	NRC, SARAO + (TM, SDP)	2.0	A. Peens-Hough M. Rupen			• Filling system gaps • Telescope Team issue	SKA011 SKA075 SKA156 SKA160 SKA176
TT MID follow-up: VLBI Requirements (RT13) - System level issues and requirements development to support VLBI.	NRC, JIVE, University of Cambridge	0.25	M. Rupen B. Carlson P. Boven S. Roy M. Ashdown			• Filling system gaps • Telescope Team issue	SKA011 SKA075
TT MID follow-up: SKA-Mid Wide Area Mapping (RT14) - System level issues and requirements development to support observing at higher than sidereal rate.	SARAO, NRC, University of Cambridge, STFC.	0.5	H. Niehaus M. Ashdown M. Rupen L. van de Heever S. Williams			• Filling system gaps • Telescope Team issue	SKA011 SKA075
TT MID follow-up: Transient Buffer Implementation (Issue #15) - System level issues and requirements development to support transient buffer.	NRC, JIVE, University of Cambridge	1.0	M. Rupen B. Carlson P. Boven S. Roy M. Ashdown			• Filling system gaps • Telescope Team issue	SKA011 SKA075

Construction Proposal Development

- Construction Proposal Workshop 2
  - Discuss timing; must have WBS, resource loaded integrated project schedule (time-phased staffing of all resources), projected contracting strategies
  - PMCS tracking and tools
  - Business systems support (tools and staff)

  - Present and challenge in detail (resources, timing, etc) with observatory staff (includes partner country staff)

Early Production Arrays - Objectives

The Early Production Array is intended to be a representative end-to-end system based on the SKA reference design, that is the result of system CDR. The EPA will be a prototype integrated system built on the intended infrastructure.

The objective of the EPA is to reduce the risks associated with the roll-out of the telescope in terms of cost, design and performance.

- Verify system performance
  - Not a continuation of the Design phase!
- Work to debug, optimize and improve the system performance
- Remediate components which do not meet requirements

The impact of the EPA will increase when as many sub-systems as possible (hardware and software) are available for integration into the Early Production Array, even if in rudimentary or prototype form.

Considerations

- The scope of the work should be within the planned construction work, but limited additional cost is imposed on the project.
- Costs agreed in the EPA are considered as credits to SKA construction contributions once the IGO is enabled.
- May limit the advantages of open tender for WBS elements.
- Development potentially delays construction (parallel effort in early stages).

Early Production Arrays

- Boundary Scenarios for achieving goals of EPA
  - 1) Bridging activity: EPA work is performed by SKAO & Consortia membership using existing or extended agreements; not under cost cap for construction.
    - No risk to construction effort or costs.
    - Incurs additional costs; overall construction + EPA cost is higher than agreed-upon cost cap.
    - To achieve risk reduction, modified operation from pre-construction required.
  - 2) Construction activity: EPA work is performed under IGO by Observatory.
    - Maintains cost agreements and commitments.
    - Utilizes IGO benefits (e.g., tax exemptions) and systems (procurements, contracting, etc).
    - IGO schedule provides later system verification; little ability to modify production as a result.
  - 3) Construction activity performed during transition phase leveraging as much of the intended IGO organizational process as possible.
    - Provides earliest system verification; provides earliest production verification.
    - Maintains cost agreements and commitments.
    - Maximum risk reduction: Verifies both technical and organizational systems (use project management control systems for construction).
    - Additional risks incurred due to transition phase between company partnerships and IGO (procurement, contracting not in place, potential loss in competitive contracting, etc)

EPA Verification

- Verify hardware and software product interfaces
- Verify basic operator interface to control the system and to monitor system health
- Verify the available functionality provided by SaDT NMGR, NSDN and SAT.LMC
- Verify science data link performance between DSH and CSP over direct connection between DSH and CSP
- Verify non-science data link performance between pedestal-located NSDN and MID-CPF-located NSDN
- Verify non-science data connectivity between NSDN and all NSDN-connected equipment at all locations including pedestal, MID-CPF and the Operations Control Centre
- Verify correlator products
- Obtain and verify the Dish pointing model for each Dish, using interferometry
- Obtain the position for each Dish
- Perform delay calibration
- Perform delay tracking
- Perform baseline delay and phase calibration
- Obtaining fringes, phase closure and amplitude closure
- Verify time and frequency reference accuracy and stability using interim CLOCKS solution
- Verify gain and phase stability
- Verify channelisation performance
- Verify frequency agility
- Perform bandpass calibration
- Verify correlator efficiency
- Start measurements of polarization performance
- Start to verify tied-array beamforming functionality
- Verify overall system sensitivity
- Measure antenna voltage patterns and surface accuracy on the sky
- Measure polarization leakage (at least on-axis)
- Verify calibration
- Verify reference pointing
- Verify EMI requirements

EPA Scope

- EPA costs are constrained by the value provided to the construction phase (Scenario 3)
- Value assessed through risk mitigation and resultant asset value

Value = [Δ Risk Exposure – Additional Incurred Costs – Additional Risks]
+ Asset Value

Δ Risk Exposure =
$\sum$ (Risk Exposure)$_{\text{Construction (Monte Carlo 80\% probability)}}$ –
$\sum$ (Risk Exposure with EPA)$_{\text{Construction (Monte Carlo 80\% probability)}}$
= Risk Reduction due to EPA activity

Note:

Additional Incurred Costs of EPA: e.g., limited production increased costs, additional mobilization/demobilization, earlier staff ramp up); note assumes construction value handles the tax implications of pre-IGO activity.

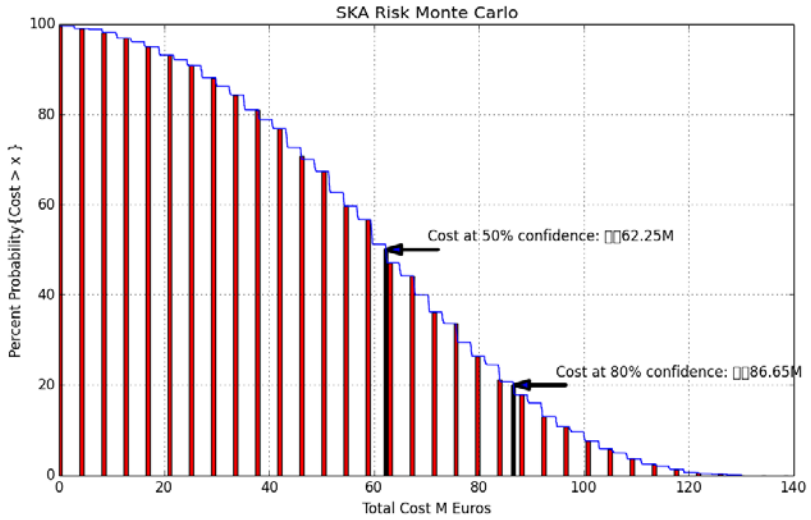
Additional Risks incurred due to EPA: e.g., higher costs due to assigned rather than competed contracts, incomplete understanding of system design (if initiated before system CDR completion).

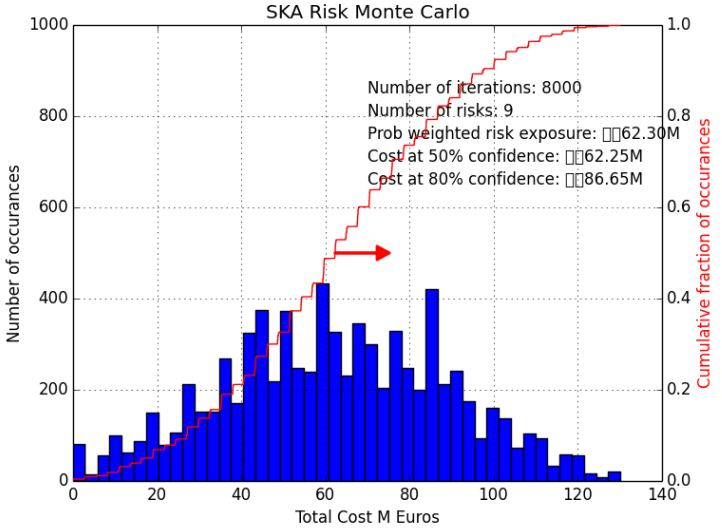
Construction Risk Management

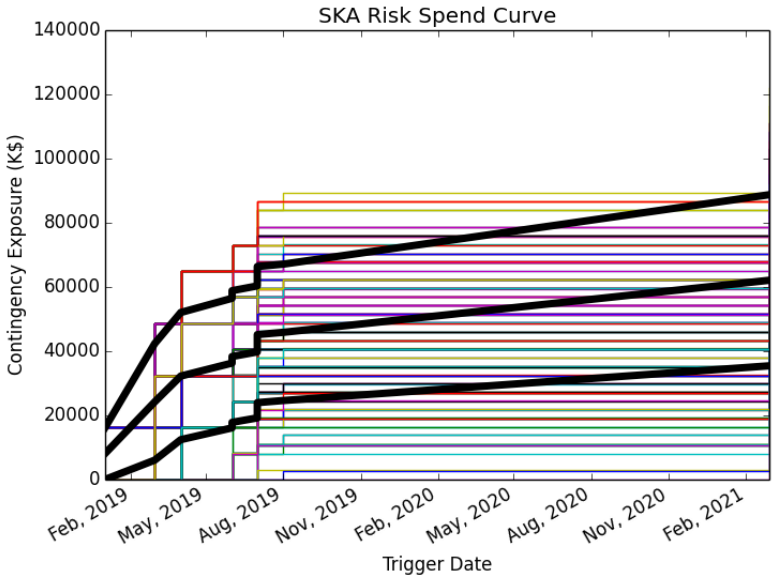
Risk ID# (Hover)	Edit Risk (Click)	Title	Review Status (days)	Trigger Date	Probability	Possible Tech Margin Remedy	Non-labor Cost (Current €)	Schedule Cost (2018 €)	Expected Exposure Cost	Expected Exposure Cost (then-year)	Estimator	Row # Sort Total Cost
VER-186	Detail & Edit	Missing or inadequate L1 requirements identified during integration and verification	0	2019-03-01	50%	No	$100 K	$32,400 K	$16,250 K	$17,240 K	Stringhetti	1
ILS-140	Detail & Edit	Product deliveries fail to meet quality or schedule requirements	0	2021-03-01	50%	No	$0 K	$32,400 K	$16,200 K	$18,233 K	Stevenson	2
PO-152	Detail & Edit	Procurement complexity impacts schedule	0	2019-04-01	50%	No	$0 K	$16,200 K	$8,100 K	$8,593 K	Hastings	3
CS-148	Detail & Edit	SAFe implementation requires additional time and resources	0	2019-01-01	50%	No	$0 K	$16,200 K	$8,100 K	$8,593 K	Miccolis	4
VER-184	Detail & Edit	Integration and Verification require longer time than planned pushing schedule.	0	2019-07-01	50%	No	$0 K	$10,800 K	$5,400 K	$5,729 K	Harman	5
CS-153	Detail & Edit	TM Time resolution not sufficient for synchronized command execution.	0	2019-06-01	50%	No	$50 K	$8,100 K	$4,075 K	$4,323 K	Rees	6
LOW-16	Detail & Edit	LOW Site development delayed	0	2019-06-01	25%	No	$100 K	$8,100 K	$2,050 K	$2,175 K	Austin	7
VER-164	Detail & Edit	Site RFI integrity compromised by site activities	0	2019-07-01	50%	No	$150 K	$2,700 K	$1,425 K	$1,512 K	Stevenson	8
VER-160	Detail & Edit	Insufficient power to support integration and verification	0	2019-08-01	25%	No	$100 K	$2,700 K	$700 K	$743 K	Austin	9

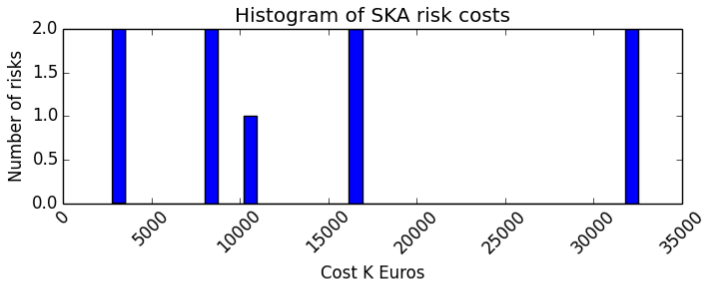
The total expected exposure cost in FY2018 € is: € 62300 K€ The total expected exposure cost in then-year € is: € 67140.73 K€

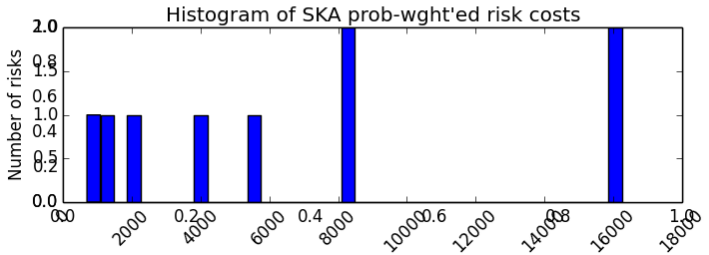
Risk Monte Carlo Modeling - EPA











EPA Scope

Value =

Δ Risk Exposure + Asset value

= Risk Reduction from EPA

Asset Value: Construction WBS Costing (~20M€).

Risk Reduction Value =

115M€ – 84M€ = 31M€

+ 20M€

=51M€ is the Upper Envelope for both MID/LOW EPA for all stages

- ~10M€ for additional costs, exposure

= **~41M€ for EPA Activity**

Further work:

- Need to review estimates
- Need to review, subtract additional costs
- Need to review, subtract new risk exposure from EPA

EPA Management & Execution

RASCI	High Level																
Activity	SKA Board IGO Council	SEAC	EF	DG/DDG	BFA	PD	SR PM	HOST HOC	Site Mgr	HPMG	HENG	HCS	EPM	DENG	MA		
CONSTRUCTION PROJECT	I	C	-	C	S	A	R	S	S	S	S	S	S	S	S	R	RESPONSIBLE
EPA SUB-PROJECT	I	C	S	C	S	A	R	S	S	S	S	S	S	S	S	A	ACCOUNTABLE
	Detail Level 1															S	SUPPORTS
																C	CONSULTED
Activity	IGO Council	SEAC	EF	DG/DDG	BFA	PD	SR PM	Host HOC	Site Mgr	HPMG	HENG	HCS	EPM	DENG	MA	I	INFORMED
HEALTH, SAFETY, ENVIRONMENT	I	I	-	A	S	S	S	R	S	S	S	S	S	S	S		
FUNDING	R	I	-	A	S	S	S	S	I	S	S	S	I	I	S		
PROCUREMENT, CONTRACTING	C	I	-	C	R	C	A	S	S	S	S	S	S	S	S	SEAC	SCIENCE & ENGINEERING ADVISORY GROUP
ASSET MANAGEMENT	A	I	-	R	S	S	S	C	C	S	S	S	S	S	S		
PROJECT CONTROLS. (ERP, EVMS, PRIMAVERA)	I	I	-	I	S	S	R	S	C	A	C	C	R	C	I	EF	EPA Funding Group
CONSTRUCTION DESIGN	C	S	-	C	-	S	S	S	C	S	A	S	C	R	S	DG	DIRECTOR GENERAL
HOST COMPLIANCE, PERMITTING	C	I	-	C	S	S	A	R	S	I	I	I	I	I	S	DDG	DEPUTY DIRECTOR GENERAL
CONSTRUCTION DEVELOPMENT	S	S	-	C	S	S	A	C	S	S	S	S	S	R	S	BFA	BUSINESS, FINANCE, ADMIN
VERIFICATION	I	I	-	C	I	S	A	S	C	C	R	C	I	S	C	PD	PROGRAMME DIRECTOR
QUALITY ASSURANCE	I	I	-	C	I	A	S	S	S	S	S	S	S	S	R		
Activity	Members	SEAC	EF	DG/DDG	BFA	PD	SR PM	Host HOC	Site Mgr	HPMG	HENG	HCS	EPM	DENG	MA		
HEALTH, SAFETY, ENVIRONMENT	I	I	I	A	-	S	S	R	S	S	S	S	S	S	S		
FUNDING	R	I	R	A	S	S	S	S	I	S	S	S	I	I	S	SR PM	SENIOR PROJECT MANAGER
PROCUREMENT, CONTRACTING	C	I	C	C	C	C	A	R	S	S	S	S	S	S	S	HPMG	HEAD PROJECT MGMT GROUP
ASSET MANAGEMENT	A	I	C	R	S	S	S	C	C	S	S	S	S	S	S		
PROJECT CONTROLS (ERP, EVMS, SCHEDULE,)	I	I	I	I	-	S	R	S	C	A	C	C	R	C	I	HENG	HEAD ENGINEERING
EPA DESIGN	I	S	C	C	-	S	S	S	C	S	A	S	C	R	S	HCS	HEAD COMPUTING & SOFTWARE
HOST COMPLIANCE, PERMITTING	I	I	C	C	-	S	A	R	S	I	I	I	I	I	S	EPM	(AREA) PROJECT MGR
EPA DEVELOPMENT	I	S	S	C	-	S	A	C	S	S	S	S	S	R	S	DENG	DOMAIN ENGINEER
VERIFICATION	I	I	I	C	-	S	A	C	C	C	R	C	I	S	C	MA	MISSION ASSURANCE
	Detail Level 2																
Activity				DG/DDG	BFA	PD	SR PM		Site Mgr	HPMG	HENG	HCS	EPM	DENG	MA		
WORK PACKAGE BUDGET AND																	

SQUARE KILOMETRE ARRAY

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