Quality, Safety, and Risk Management

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ICNO/Upgrade Project - NSF Site Visit Review
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1.1.3.1 Risk Management Plan

- Risk Management Strategy & Approach
  - The basic risk management philosophy of the IceCube Upgrade Project is to identify threats to the successful completion of the Project.
  - With the vast technical experience within IceCube, the nature of these threats is understood, and mitigation plans are developed to remove or minimize the impact of these risks.
  - Once a risk is identified, someone is assigned formal responsibility for managing it through mitigation and closure.

1.1.3.1 Risk Management Plan

- Scope, Roles & Responsibilities
  - This plan governs all IceCube Upgrade WBS Collaborators who have Upgrade Project Budgets and Schedules. We manage some External Risks that apply to Suppliers to the IceCube Upgrade Project.
  - Everyone is responsible for identifying risks.
  - L2s Update Risk Registry(RR) in SharePoint.
    - Minimally, 1 x per Quarter. Updates to be recorded in Change Log.
    - Goal is to update RR as new risks are identified or old risks are retired.
  - Quality and Safety Manager:
    - Ensures the Quarterly RR Review
    - Maintains the RR

1.1.3.1 Risk Management Plan

- Risk Registry (RR)/ Risk Identification
  - The RR includes a description of all risks that are deemed to be important to achieving Project success, along with an assessment of those risks that allows risk to be prioritized for effective risk management.
  - Risks are depicted in the Risk Registry (RR) with a Title, Description, Risk Owner, Risk trigger, and a Mitigation Plan.
  - Risks are categorized as: Technical, External, Organizational, and Project Management

Risk Identification and Tracking				Current Risk Response				
Risk ID	Associated WBS	Risk Description	Risk Title	Risk Owner	Risk Occurrence Timeframe	Risk Handling Approach / Response	Risk Trigger	Risk Mitigation Plan and Actions
ORG6	1.2	Serious injury occurs and halts drilling or cancels a season as a result.	Serious Injury	Drill Lead TH	Any Season	Mitigate	Any number of reasons	Thorough safety training as well as systems and individual hazards analysis performed throughout the EHWD
EXT10	1.2	Drilling into obstructions/cables - The tight array is planned in an area with possible "old station" debris	Drill obstructions	Drill Lead TH	21/22 or 22/23	Mitigate	Unknown	Plan ground penetrating radar survey in 2019/20 of proposed array and surrounding area
ORG7	1.1	The Upgrade Project is funded for only 5 strings.	Only 5 Strings	Hanson	21/22 and 22/23	Mitigate	Receipt of funding for only 5 strings	Receipt of KIT Funding to cover the additional 2 strings.
TECH19	1.2	Cut/Damaged Drill Cable - Equipment or unknowns end up damaging the main drill cable.	Damaged Drill Cable	Drill Lead TH	Drill season 2022-2023	Mitigate	Operator error	Proper visible flagging and markings installed
TECH23	1.2	Fire/Major Equipment Failure - A fire develops resulting in damage to equipment. Drilling is delayed 1 year.	Fire	Drill Lead TH	Drill season 2022-2023	Mitigate	Technical problems or Operator Error	Diligent Hazards Analysis, risk mitigation planning, and training. C02 fie suppression system testing in 19/20 season, procure C02 for 21/22 season.

1.1.3.1 Risk Management Plan

- Resulting Risk Exposure & Risk Cost Score
  - The Probability and Impact Matrix Table on the next page determines the Resulting Risk Exposure. The Cost Risk Score is used to determine the dollar value for each risk. The Low Estimate %, and the High Estimate % are determined from the Risk Probabilities Table. These values are factored against the Risk Cost Exposure value, with the results recorded in the RR.

Risk Identification and Tracking			Post-Mitigated Risk Evaluation							Risk Cost Calculation		
			Probability and Impacts				Resulting Risk Exposure					
Risk ID	Associated WBS	Risk Description	Risk Probability	Impact on schedule	Impact on cost	Impact on technical performance	Schedule Risk Score	Cost Risk Score	Technical Performance Risk Score	Risk Cost Exposure	Low Estimate	Average Estimate
ORG6	1.2	Serious injury occurs and halts drilling or cancels a season as a result.	Low	Low	Low	Low	Low	Low	Low	$983,000	$49,150	$147,450
EXT10	1.2	Drilling into obstructions/cables - The tight array is planned in an area with possible "old station" debris	Low	Very low	Very low	Low	Low	Low	Low	$70,000	$3,500	$10,500
ORG7	1.1	The Upgrade Project is funded for only 5 strings.	Very Low	Very Low	Very Low	Very Low	Low	Low	Low	$500,000	$5,000	$15,000
TECH19	1.2	Cut/Damaged Drill Cable - Equipment or unknowns end up damaging the main drill cable.	Low	Very low	Low	Low	Low	Low	Low	$70,000	$3,500	$10,500
TECH23	1.2	Fire/Major Equipment Failure - A fire develops resulting in damage to equipment. Drilling is delayed 1 year.	Low	Moderate	Moderate	Low	Moderate	Moderate	Low	$983,000	$245,750	$368,625

1.1.3.1 Risk Management

- Probability and Impacts
  - The risk score is determined from the tables below.

Probability and Impact Matrix for Risk Scoring					
	Impact				
Probability	Very Low	Low	Moderate	High	Very High
Very High	Moderate	Moderate	High	High	High
High	Low	Moderate	High	High	High
Moderate	Low	Moderate	Moderate	High	High
Low	Low	Low	Moderate	Moderate	Moderate
Very Low	Low	Low	Low	Low	Moderate

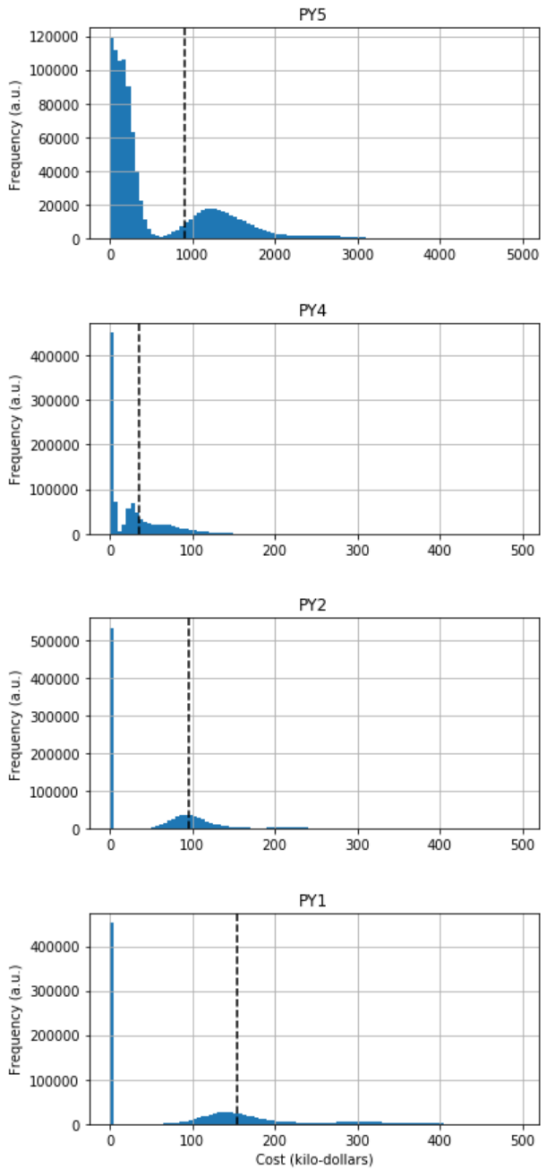
Risk Probabilities Table		Limits for Calculation	
Probability of Occurrence Descriptor	Numerical Ranges	Low	High
Very Low	< 5%	1%	5%
Low	5% - 25%	5%	25%
Moderate	25% - 50%	25%	50%
High	50% - 75%	50%	75%
Very High	> 75%	75%	95%

1.1.3.1 Risk Management

- The Estimate of Cost & Contingency comes from 2 sources:
  - 1. Cost Uncertainty:
    - Level 2 Managers evaluated uncertainty of cost estimate at each Level 4 WBS as described in the PEP. This was turned into a percentage at L4, applied to the L4 element cost, and then rolled up to the Project level.
    - The total uncertainty calculated in this manner is equal to $1,324,988, or 7.71 % of the NSF budget. This fraction, 7.71 %, was then applied to the yearly project cost profile.
  - 2. Risks identified in the Risk Register were used as inputs to a Monte Carlo Risk simulation
    - Details on next slide

1.1.3.1 Risk Management

- First, risks were collated by project year where the risk is anticipated to be retired. For each project year, 1 million probabilistic simulations of possible risk outcomes were performed as follows:
  - Risks for a given project year were iterated over.
  - Each risk was assigned a probability of occurrence in the current scenario. This probability was assigned by first associating a numerical high probability and low probability based on the risk's probability in the Risk Register: very low, low, moderate, high, and very high. For example, risks assigned the 'Low' probability have a low probability of 5% (0.05) and a high probability of 25% (0.25). The probability in a given scenario was selected with a uniform random variate with these limits.
  - The occurrence of that risk was simulated by generating another uniform random variate on the interval [0, 1). If the resulting number was less than the probability assigned in the previous step, the risk was realized: the cost associated with the risk was multiplied by a random normal variate with mean 1.0 and sigma 0.25 to simulate a 25% uncertainty in the evaluation of the risk's true cost.
  - The sum of realized risk costs in each of the million simulations was input into a histogram to arrive at the distribution of risk costs in a given project year (see figure).
  - The resulting histograms for each project year were evaluated to find the cost which separated the bottom 70% of the distribution from the upper 30% of the distribution (dotted black line in figure). This is the cost which was sufficient to mitigate risks in 70% of the simulated risk scenarios.



1.1.3.1 Risk Management

- Contingency Allocation by Project Year
  - Contingency = Cost Uncertainty + Risk

Project year	PY1	PY2	PY3	PY4	PY5
Remaining risk exposure based on qualitative and quantitative analysis	$1,252,465	$1,026,605	$965,689	$965,689	$940,845
Difference to prior year		$225,860	$60,916	$0	$24,844
Simulated risk per year with 70% confidence level	$155,000	$95,000	$0	$35,0000	$900,000

*$0 of Risk retired in PY3

1.1.3.1 Risk Management

- Summary
  - It is evidenced in the Risk Registry(RR) that the IceCube Upgrade Project has a good plan to identify and deal with Risks, contain costs, and maintain schedule.
    - Everyone is responsible for identifying Risks.
    - A current Risk Register contains all Risks and Mitigation Plans and resides under control in SharePoint.
    - Resulting Risk Exposure & Risk Cost Score are captured in the RR.
    - Probability and Impacts are evaluated.
    - Estimates of Project Costs and Contingencies are determined, figuring in Cost Uncertainty.

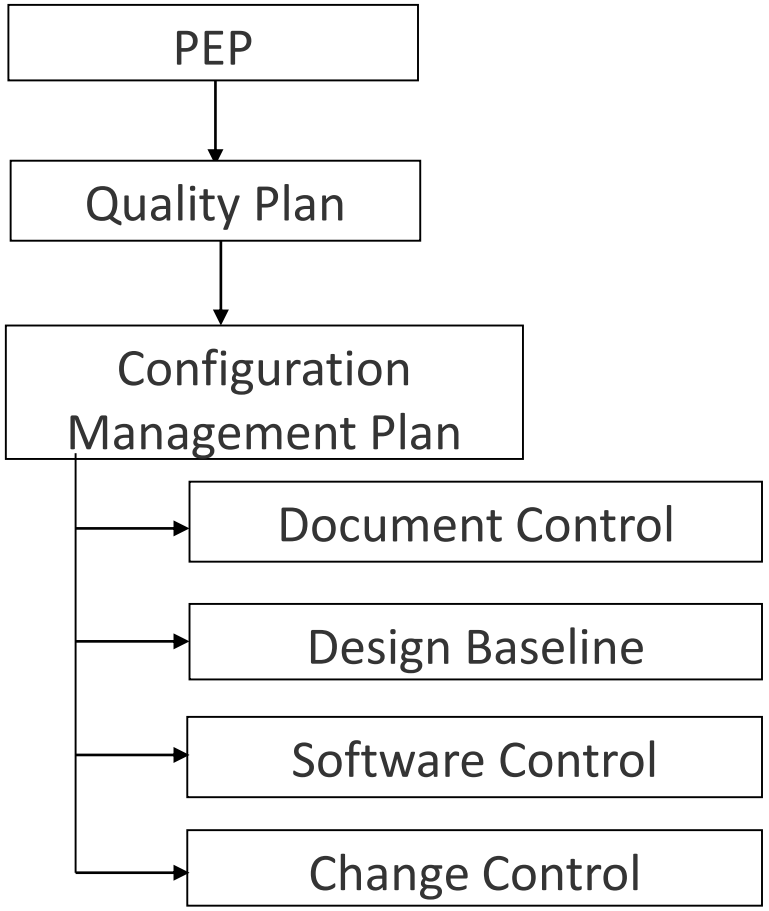
Quality Plan Highlights

- Quality Plan (9000-0003)
- Quality Process Hierarchy
- Quality Plan Interactions
- Configuration Management Plan (2019-007)
  - Document Control
  - Design Baseline Control
  - Software Control
  - Change Control
- Manufacturing Plan
- Training

Quality Plan (9000-0003)

- Describes how the IceCube Upgrade Quality Program will be conducted
- Flow down from Project Execution Plan (PEP)
- Includes high level descriptions of:
  - Project Team
  - Design
  - Configuration Management
  - Manufacturing
  - Corrective and Preventive Actions
  - Training

Quality Process Hierarchy



Quality Plan Interactions

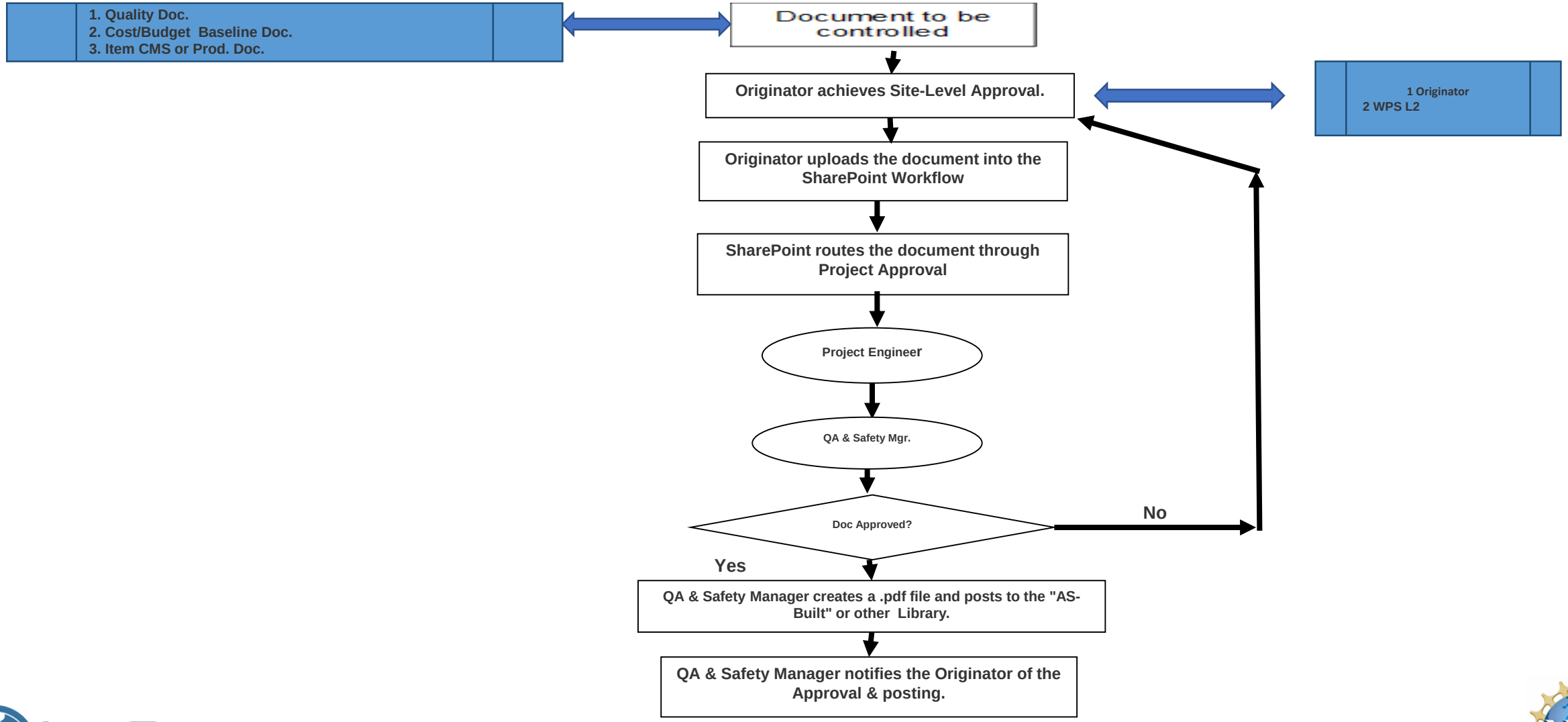
Configuration Management Plan

- Contains:
  - Document Control
  - Design Baseline
  - Software Control
  - Change Control
- Purpose:
  - Traceability of design and components
  - [Engineering Requirement Docs.(ERDs), Design Status & Notes (DSNs), Config. Mgt. Docs (CMDs), and Interface Definition Documents (IDDs.)]
  - Formal process to manage changes
  - Maintenance of s/w, f/w configurations for test and operations
  - Device improvement

Document Control

- SharePoint:
  - Project repository for documents (1-stop shopping)
    - Umbrella over local document control repositories
    - Eliminates need to access multiple websites
  - Repositories for:
    - Quality Documents
    - Design reviews, white papers, action item tables, In-process documents; multiple libraries
    - Design Baseline Documents
    - PEP support documents
- Status:
  - Configuration Management Plan Reviewed.
  - Document Control Plan developed.
  - Work flow for Document Approval in use.

Document Control-Flow Chart



Design Baseline

Interaction with PEP, Mfg. Plan, document control and change control processes

- Define design, manufacture, installation and service of hardware--In Design Baseline Library
- Traceability of components and devices
- Configuration Item = Item
- Each Item is described by up to 4 CMS Documents:
    - CMD (Config. Mgt. Doc.); DSN (Design, Status, Notes); ERD (Engr. Req. Doc.) and IDD (Interface Definition Doc.
- Includes: Examples of items in Upgrade Project (hierarchical series):
    - Upgrade Detector
        - Upgrade String
            - mDOM
                - mDOM HV
                    - **mDOM HV Test Procedure**
- The Hardware Controls may include: requirements, specifications, assembly drawings, assembly procedures, BOMs, test procedures, travelers, installation/commissioning procedures, all forms.

Software Control

- The IceCube Upgrade software will be controlled in accordance with the M&O Plan.
  - Testing emphasized in development
  - unit tests for individual components / functionality
  - integration and system testing at SPTS
  - Releases named, numbered, and tagged in version control system
  - All major changes (DAQ, DOM mainboard software) reviewed at collaboration-wide teleconference before rollout
  - 8- to 24-hour test runs of release candidates at pole – data quality vetted by operations group

Software Control (cont.)

- All source code under revision control (subversion, git)
  - Bugs / features tracked in issue tracking system (e.g. Mantis, GitHub Issues) – severity, owner, detailed description, etc. -ticket numbers referenced in code check-ins and release notes
  - Changes discussed on bi-weekly development teleconferences

0008540			bugs	minor	new (jkelley)	**2018-12-18**	config-scripts: running outside of script directory doesn't work
0008560			[pdaq-user] software	minor	new	2018-12-10	Run `ssh-keyscan` as part of pdaq install?
0008559			software	minor	new	2018-12-07	Replay runs should write to HitSpool
0008558	3		[dash] software	minor	resolved (dglo)	2018-12-03	We need a way to switch between Python virtualenv instances
0008551	1		[dash] bugs	minor	resolved (dglo)	2018-11-26	RemoveHubs - Dave broke this!
0008519	1		[pdaq-user] bugs	minor	resolved (dglo)	2018-11-26	Add RemoveHubs.py as a `pdaq` subcommand

Change Control

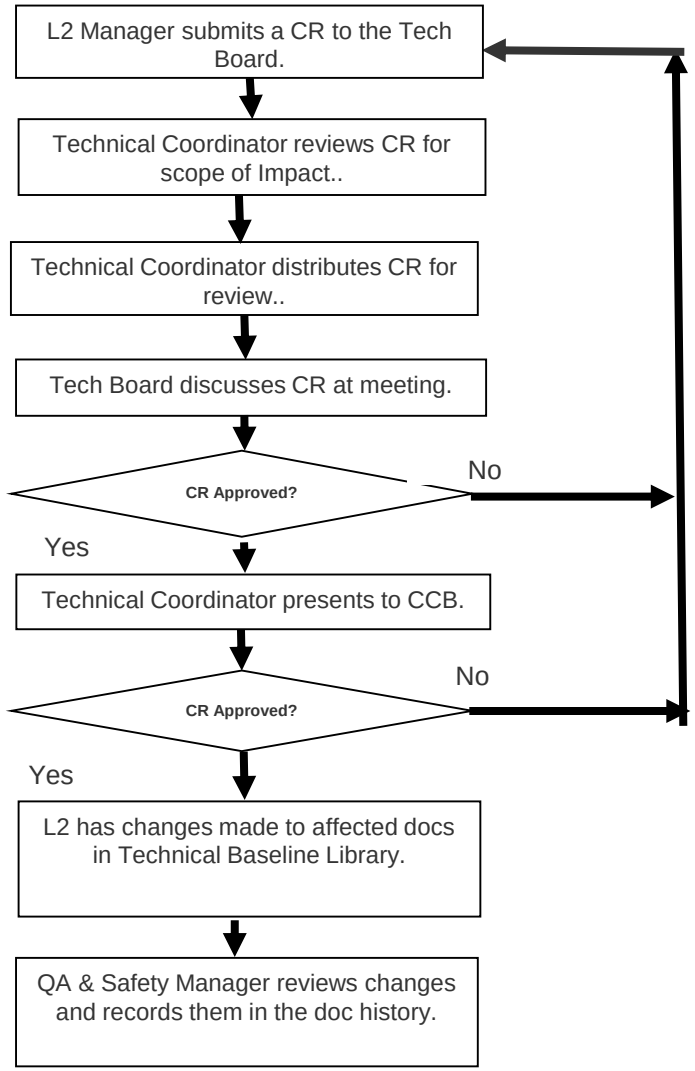
- Defines process for updating technical and project baseline documents
  - 3 classes of changes
    - **Class 1**- Affects science goals, total cost >/= $150K, >6 month project schedule slip (NSF approval)
    - **Class 2**- Affects project objectives, L2 cost, >3 month L2 schedule slip, performance, safety, reliability, crosses interfaces (Project Director approval)
    - **Class 3**- Does not affect cost/schedule baselines, nor form, fit, or function of material. (L2 Approval)
  - Project Change Control Board (CCB)
    - Chaired by Project Manager
    - Reviews all Class 1 & 2 changes
    - Reviews include impact on cost, schedule, safety, quality, verification, in-process materials
    - The CCB was exercised during cost baseline process

How change is managed in project

- Change Owner or CCB Member initiates a CR (Change Request) for a WBS area.
- Technical Coordinator reviews CR for scope of impact
- Technical Coordinator distributes CR for review by appropriate parties including:
  - Project Engineer (reviews technical accuracy, item scope, and technical impacts)
  - Quality & Safety Manager (reviews impacts on Quality and Safety)
  - Project Controls Manager (reviews impacts on budget and schedule)
  - Logistics/Ops Manager (Reviews impacts on deliverables and logistics)
  - Principal Investigator or assignee (Reviews Science impact)
  - Other L2 Managers, as applicable (Review impacts to their area)
- CR is discussed at next Tech Board teleconference
- CR is discussed and approved or denied at next CCB teleconference
- Changes are made by L2 Mgr or assignee to affected docs in Technical Baseline Library
- Changes to documentation are reviewed and noted in document history by Q&S Manager

Change Control-Flow Chart

Change Request Form



Manufacturing Plan

- Process control
  - Common procedures
- Assembly/test procedures/records
- Identification & traceability
- Device acceptance
  - Final acceptance
- Calibration of test equipment
- Non-conforming material
  - Project Office MRB with each mfg. site to review disposition of material
- Receiving inspection
- Handling & storage
- Selection of Vendors:
  - Defined criteria based upon the vendor's ability to meet specs and schedule.

Training

- Paramount to Quality/Safety Objectives
  - Very difficult to institute quality processes at multiple locations without appropriate training
- IceCube Upgrade Training:
  - Safety Training: No one can get hurt
    - (SafeStart/OSHA prescribed Training/First Aid/CPR/Defib.)
  - Driller Training: Folks must operate equipment properly and Safely
  - Document Control
  - D-Egg & mDOM manufacturing processes
  - Job-Related Seminars as appropriate

General Safety Plans

- IceCube
  - General/ Job Specific Training: Completed: 08/19
  - Review: Proc./Has: Completed: 08/19 and at Pole throughout season
  - Safety Miscellaneous: Completed: 08/19
    - PPE: Hearing Protection
    - Fire Safety: Evacuation
    - General Hazards
  - Advanced Safety Assessments: Performed in Fall at Pole
  - METRICS: see slide
  - Ice Safety Activities: see slide
- ASC/IceCube
  - Walks Through/Drills: Performed by Safety Manager
- SafeStart Training for All- "Keep your Head in the Safety Game"
  - "Also, watch each other's back!"
    - SAFETY CONTACT
  - MAZ was re-certified as SafeStart Trainer: 06/19
  - Drillers/Deployers received a refresher course:08/19 and at Pole.

2020/21 IceCube Upgrade Safety Plans

- We continue to strive to make IceCube Safety everyone's responsibility at the Pole and across the Project.
- Incident Reporting was effective in Gen 1!
    - More people paid attention to what they were doing.
    - Still some IR's show inattentiveness causing hiccoughs.
- NANA systems training: SafeStart
    - Emphasis: Keep Your Head in the GAME! (eyes/mind on task)
    - Refresher SafeStart course this summer.
    - Will include DuPont spin on keeping others safe
- Advanced Safety Audits this Summer and through the Pole Season, throughout the Project.
- Review of Safety Manual and EHWD Procedures
- Process & Equipment Hazard's Analysis Review
- OSHA prescribed Training: Fall Protection/LOTO/Confined Space
- Hazardous Energy Training as required: could be: Electricity, Welding, Burner, Rigging.
- Prevent All Foreseeable Injuries!

Annual Polar Safety Activities (19/20)

Task #	Task type	Task	IceCube / ASC
1	Preparation / Setup	**Drill Equipment/ Process Start-Up Safety Check**	IceCube
2	Preparation / Setup	**Check and Weigh Fire Extinguishers**	ASC
3	Preparation / Setup	**Fire Team Walk-through**	N/A for 19/20
4	Preparation / Setup	**E-Stop Testing**	IceCube Initiated in 19/20
5	Preparation / Setup	**Smoke/CO Monitor testing**	IceCube
6	Preparation / Setup	**Mass Casualty Drill**	ASC performed some
7	Preparation / Setup	**Check GFCI outlets.**	IceCube
8	Preparation / Setup	**Inspect Slings/ Fall Protection Harnesses**	IceCube (New harnesses for 19/20
9	Shutdown	**Drill Equipment/ Process Winterization Safety Check**	IceCube

Metrics: 19/20

- Days w/o Lost Time Injury = 0
- Days w/o Reportable Injury = 0
  - Reportable: any injury requiring more than basic first aid treatment.
  - Visiting the Doctor, even if the Doctor just looks at injury, counts as reportable
- Near Misses = 6

Incident Reporting (19/20)

- 1920-1: An individual goes off on their own to work.
  - Dangerous Act: violates policy of communication with COMMs, taking a radio, and using the "Buddy System."
- 1920-2: A winch was being used to deploy equipment down a hole. The cable hadn't been re-wound correctly, leaving a gap.
  - No one recognized this as a problem. Hence, the process required an extra 5 hours of time to retrieve the equipment out of the hole.
- 1920-3: A nut had fallen loose from the speed control knob on the winch.
  - No one paid attention to it. This inattentiveness caused a problem with the speed of the cable when deploying equipment.
- 1920-4: An icy build-up within the cable sheave on the winch was cutting into the deployment cable.
  - Deployment had to be stopped in order to save the equipment from potential loss.

Incident Reporting (19/20) cont.

- 1920-5: An ASC heavy equipment crew was excavating near a wind turbine, damaging an IceCube fiber-optic cable and an ARA high power cable.
  - There was a lack of communication between ASC and IceCube as to the presence of the cables.
- 1920-6: An individual made contact with live ELV (Extra Low Voltage) wires in the ICL during a live system debugging.
  - This incident occurred due to inattentiveness and a lack of a procedure for debugging a live system.

Advanced Safety Auditing (19/20)

- Continuous Assessments all Season
- Maximum assessments planned
  - Auditors look for “Eyes on task/Mind on Task” scenarios.
  - Drill Camp and other areas
    - HPP, MHP,SES
- Interesting Notes:
  - Assessments were typically well-received, now, as in GEN 1.
  - Hazards abound, but People are aware and trigger.
  - People typically do not work in “Harm’s Way.”
  - Proper PPE and tooling was typically in use.
  - Generally People felt safe.
- Actions:
  - Procure a lifting device for removal and installation of the burners to the water heaters.
  - Procure more robust and larger masks to better filter the air when working in MHPs or other buildings.

On-Ice Safety Hierarchy

- On-Ice Lead/ Safety Manager
  - Safety Lead- Drilling
    - Shift Leads
    - Deputy Shift Leads
  - Safety Lead- Deployment
  - Safety Lead- ICL
  - 4. Safety Lead-Other

Shift Leads/Deputy Shift Leads

- Model for Safe Behavior/ Support of Safety effort
- Support weekly scheduled Safety “Walk-Through” Assessments and write report.
- Write Incident Reports for areas of responsibility as required
- Conduct weekly Safety Action Meetings in own areas and take minutes.
- Initiate Safety Contacts as required

Safety Contact

- You see someone behaving in an Unsafe manner.
  - Encounter must be a positive experience to work
    - Calmly get their attention
    - Compliment them on safe behavior demonstrated
    - Discuss the Unsafe Behavior
      - You are trying to convince someone to change their behavior
      - What's the downside for them (consequences)
      - Cite from personal experience if possible.
    - Attempt to get agreement to work safely
    - Discuss other Safety Issues
    - Thank them for their time
      - At least they are thinking about the issue
      - This discussion is "Off the Record."

CO2 Fire Suppression System Issue

History:

- An accidental CO2 System discharge in MHP 3 in GEN 1; 2 fatalities due to an accidental discharge in 2018 (Mt. Newall); An accidental discharge in McMurdo (2019).
  - CO2 Fire Suppression Systems in all Drill Camp Buildings have been deactivated. IceCube wants to maintain this status throughout the Upgrade Project because CO2 Fire Suppression Systems are inherently unsafe for people.
  - An IceCube Upgrade Fire Safety Plan has been developed to keep the Drill Camp personnel and the equipment safe without any CO2 Fire Suppression System.
    - Plan submitted to IceCube Upgrade Management, ASC Fire Chief, and to the UW Fire Safety Manager
      - ASC Fire Chief concurs with the plan with some slight revision.
  - Once concurrence is achieved from all parties, then the plan will be submitted to the NSF for concurrence as well.

Safety Next Steps

- We feel that the IceCube Upgrade Safety/Training Plan has proven to sustain the Safety Levels attained in GEN1.
  - Drillers/Deployers will get a new SafeStart course: Aug. 2020 w/ refresher at Pole
  - GEN 1 Hazards Analyses will be reviewed with Drillers/Deployers: Aug. 2020
  - GEN 1 Incident Reports will be reviewed in 08/20 and annually.
  - South Pole:
    - Orientation and refreshers for all
      - Shift Hand-Offs
      - All hands Meetings!
      - Safety Audits
    - Revamp Safety Messaging System at Pole
      - In conjunction with ASC Safety Engineer
      - No more OSHA rhetoric
      - Timely SafeStart messages: Eyes on Task/Mind on Task et al.
    - Personal Safety Note from Project Manager
    - The simple plan is “business as usual”---picking up where we left off in 19/20.
- GOAL: Increased Safety Awareness/Eliminate COMPLACENCY

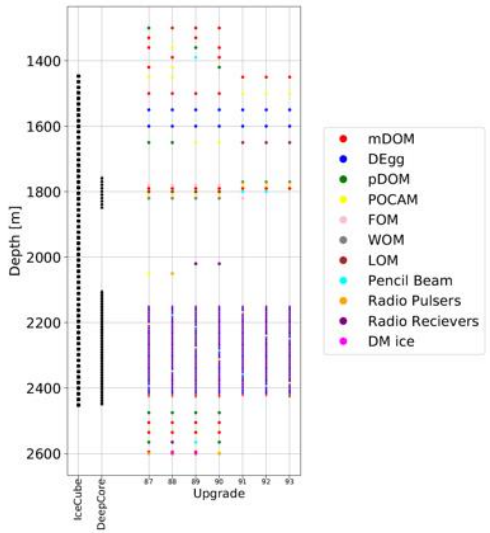
South Pole IceCube Personnel

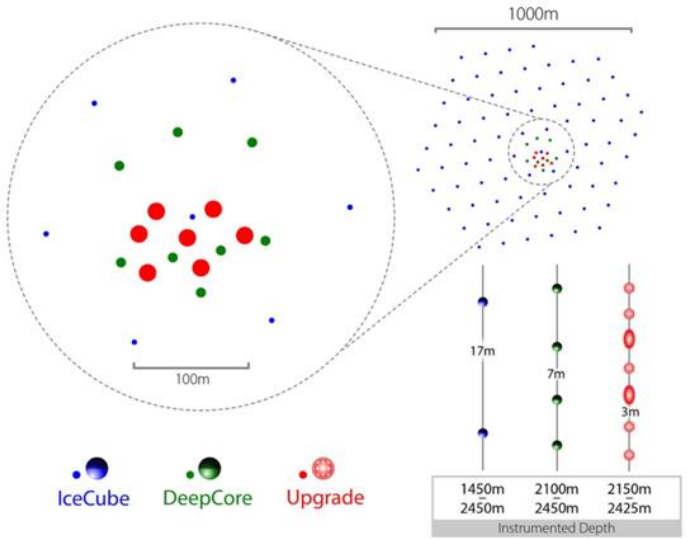
- Everyone is accountable for the safe performance of their duties and the safe operations within their areas
  - Initiate Safety Contacts as required
  - Report any unsafe condition noticed

Head in the Game?

Backup

Upgrade Scope:

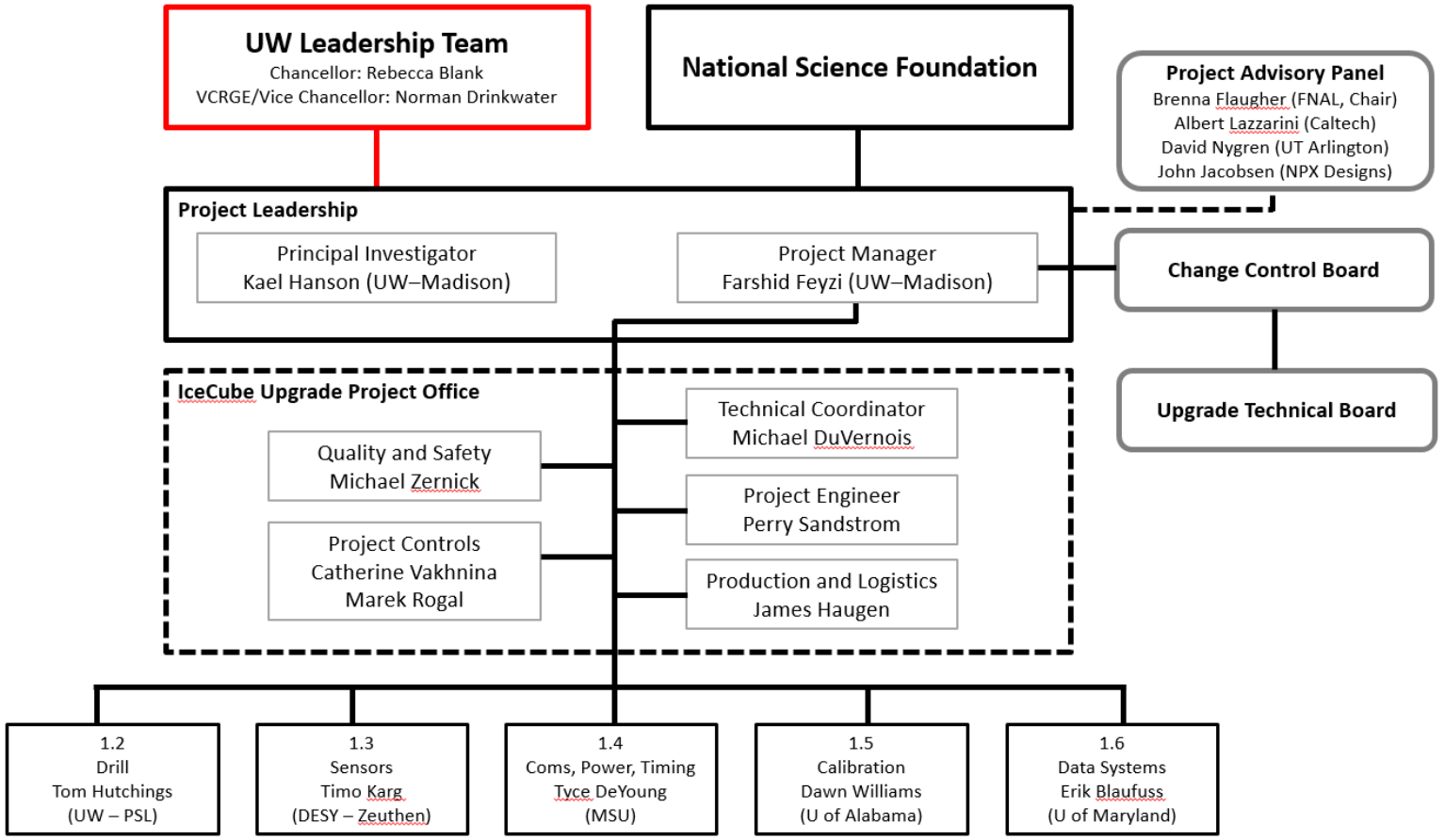




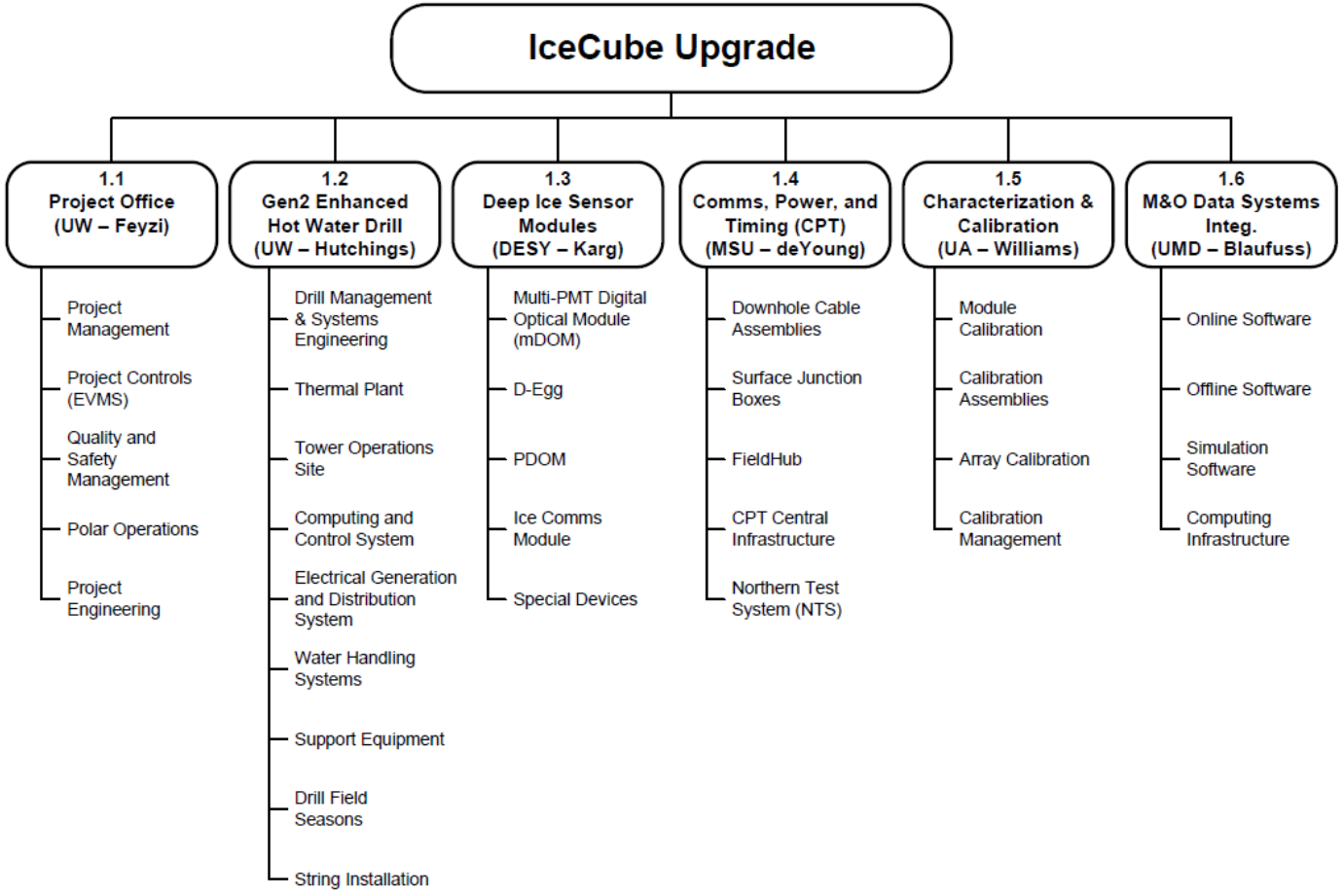
String	87	88	89	90	91	92	93	TOTAL
mDOM	55	56	58	53	61	59	60	**402**
DEgg	39	39	40	39	40	40	40	**277**
pDOM	1	1	2	1	2	4	3	**14**
WOM	2	2	1	2	1	1	1	**10**
FOM	2	2	0	0	1	1	1	**7**
POCAM	2	2	5	3	2	3	4	**21**
PB	1	2	1	2	3	1	1	**11**
PS	1	1	1	1	1	1	1	**7**
DM ice	0	0	1	0	0	1	0	**2**
RP	0	1	0	0	1	0	1	**3**
RR	1	0	0	0	0	2	0	**3**
AH	0	0	1	1	0	0	0	**2**
LOM	2	1	1	3	0	1	1	**9**
AP	2	1	2	1	1	1	2	**10**
ALL	**108**	**108**	**113**	**106**	**113**	**115**	**115**	**778**

- Upgrade Objectives:
  - Neutrino Properties
  - Recalibration and Reanalysis of IceCube Data
  - IceCube-Gen2 Research and Development (not directly funded)

Project Office and Level 2 Organization



Level 3 Organization



Configuration