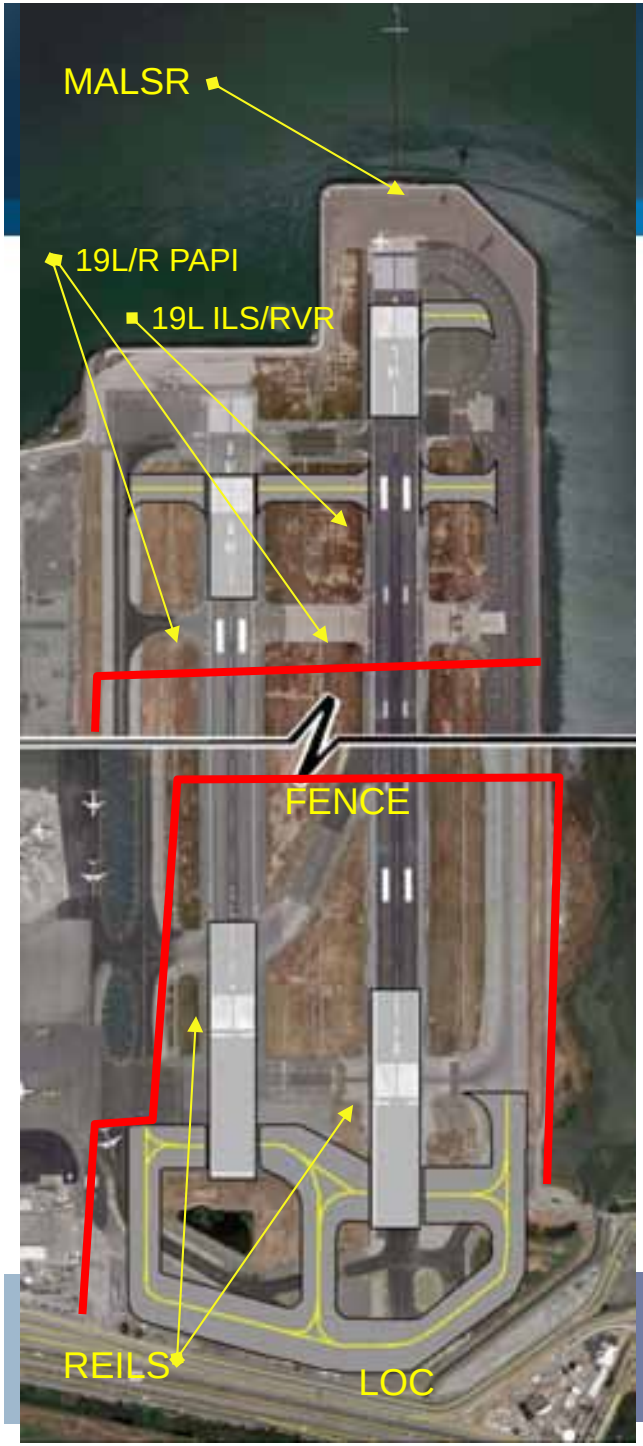
Runway Safety Area (RSA) Program
Runways 1L-19R and 1R-19L

Lalesh Sharma, P.E. **(SFO)**
Eric Gardner Jr. **(Royal Electric)**
Doron Lean, P.E. **(Lean)**


SFO Runway Safety Area Enhancements
28R
28L
1L
1R
LEGEND
NEW TAXIWAY
EMAS
RWSL DUCTBANK
TRESHOLD RELOCATION
RWSL
APPROACH LIGHTS

Displace Runway Thresholds:

1L End, 300’ South
19R End, 300’ South
1R End, 120’ North
19L End, 200’ South



Navaids	AFL
19L MALSF Relocation	R/W Edge, CTL, and TDZ
19L ILS, RVR	T/W CTL Lights
19L and R PAPIs	T/W Edge
1R and 1L REILs	LED Signage
19L Localizer Infrastructure	Sectionalizer and Ductbank
Power and Comm	AFL Cable
RWSL Ductbank and Base Cans	CCTV and other infrastructure

Installation of EMAS:

1L End 500’ EMAS bed
19R End 415’ EMAS bed
1R End 375’ EMAS Bed
19L End 410’ EMAS bed

Team Members

- Construction
  - Golden Gate Constructors
  - Royal Electrical Company
  - DACO
  - WPCS
  - Linear Options
- Inspection
  - Parsons Brinkerhoff – Civil
  - Lean Photometrics – Electrical/Navaids
  - Ghiradelli – Utiliites
  - CPM – Costing/PM
- FAA
  - Engineering Services
  - Flight Procedures
  - Local SSC
  - ADO
  - NCT
  - Flight Standards
  - SMCGS Inspectors + 20 more
- Manufacturers: (Everyone of them hit their deadlines)
  - ADB
  - Crouse-Hinds
  - Astronics
  - NBP
  - ESCO

Agenda:

- Doron – Overall Project Challenges.
- Lalesh – AFL Challenges.
- Eric – Construction/Contractor challenges.
- Doron – NAVAIDS and wrap up

Project Overview - Challenges

- Cost
  - Construction =$87M
  - Bonus =$3M
  - Preprocurement (Lighting) =$8M
  - CM/Testing/Misc. =$8M
  - Departure Metering System =$2M
  - FAA Reimbursable =$3M

  Total w/o EMAS =$111M
- Construction Duration: May 17, 2014 to August 6 = 87 days
- Approximately 50% of the total cost was electrical
- **~ $1.3 Million Per Day in Construction Cost**
- Good Quality

Major Challenges:

Major Challenges:

- Handling Change (Utilities, Existing Conditions)
- NAVAIDs compliance, Flightcheck, FAA
- Coordinate B/T Civil and Electrical.
- Delivery and Procurement of Material.
- Managing invoices and cost – Getting contractor paid correctly.
- Contractor managing resources.
- Updating Old infrastructure.
- Safety
- Other technical problems.

Risk Management Approach

- Lean – Planned, Designed, and Inspected the electrical work.
  - Ability to implement a risk management approach.
- Made sure Electrical got a seat at the table.
- Analyzed different electrical problems with probability vs. severity to quantitatively understand where the project can go wrong. Performed with stakeholders.
  - Probability:
    - 1 per 10 - Frequent
    - 1 per 1000 - Probable
    - 1 per 10000 - Remote
    - 1 per 100000 – Extremely Remote
  - Severity
    - Catastrophic
    - Hazardous
  - Used probability analysis to determine Risk

FIGURE 3 – RISK MATRIX

Likelihood \ Severity	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A					
Probable B					
Remote C					
Extremely Remote D					
Extremely Improbable E					*

High Risk
Medium Risk
Low Risk

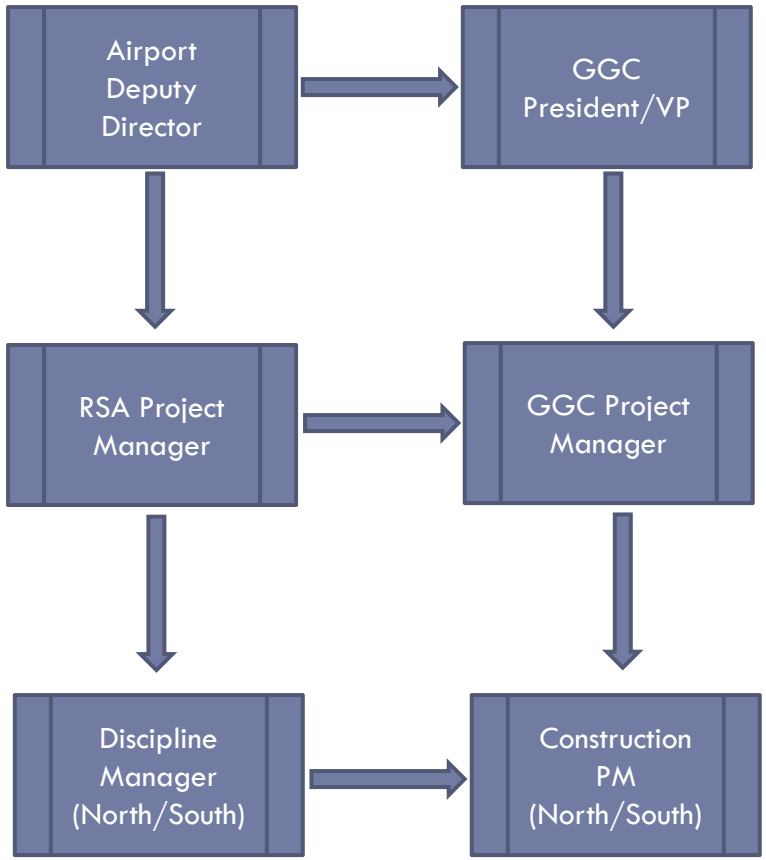
* Unacceptable with Single Point and/or Common Cause Failures

Risk Management

- Use technical experience to manage risk
- Ex. 1
  - Risk: 50 KVA Transformer falls off a truck and you can't meet flightcheck because power can't be turned on.
  - Solution: Mitigated the risk by (a) preprocuring, (b) testing, and (c) having a generator on-site.
- Ex. 2
  - Risk: Material doesn't arrive on time or arrives broken.
  - Solution: Preprocure and test when it arrives.
- Ex. 3
  - Inexperienced or a not well funded contractor could hijack the schedule.
  - Shortlist of Electrical/Civil Contractors separately.
  - Perform shortlist based on experience, expertise, and economic strength.
- 3 Day Risk Summit.
- Over 100 scenarios analyzed and mitigated.

Challenge: Handling Change

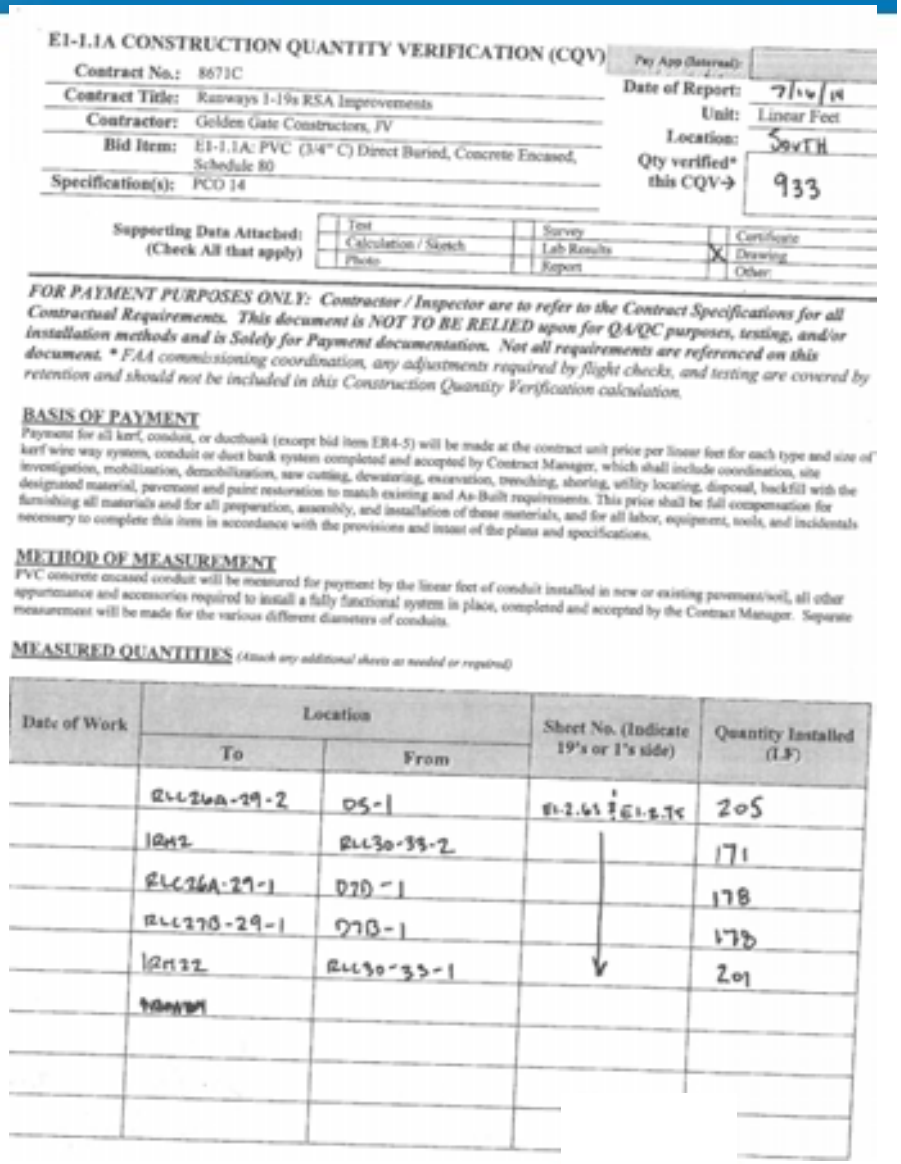
- Develop Communication at all levels including higher-ups.
- Authorize DORs/PMs (Only 4 of us) to pull the triggers on Change Orders without Approval from Higher Management or Committees.
- Paperwork to follow.
- Trust with Contractor/Engineer – Most important thing an Engineer and Contractor can do is explain their reasoning and admit mistakes.



Daily Construction Quantity Verification

San Francisco International Airport

- Agree on quantities daily with contractor and engineer.
- Define for each bid item on CQV what is included, what is retention, what is incidental:
  - Grounding, testing, backfill.
  - As-built, cleaning.
- "The first step in any relationship is to agree on what you disagree"……Henry Kissinger
- Submit daily as-built drawings with quantities.
- Pay bi-weekly.



E1-1.1A CONSTRUCTION QUANTITY VERIFICATION (CQV)

Pay App (Interval):

Contract No.: 8671C
Contract Title: Runways 1-19s RSA Improvements
Contractor: Golden Gate Constructors, JV
Bid Item: E1-1.1A: PVC (3/4" C) Direct Buried, Concrete Encased, Schedule 80
Specification(s): PCO 14

Date of Report: 7/14/19
Unit: Linear Feet
Location: South
Qty verified* this CQV→ 933

Supporting Data Attached: (Check All that apply)

	Test		Survey		Certificate
	Calculation / Sketch		Lab Results	X	Drawing
	Photo		Report		Other

*FOR PAYMENT PURPOSES ONLY: Contractor / Inspector are to refer to the Contract Specifications for all Contractual Requirements. This document is NOT TO BE RELIED upon for QA/QC purposes, testing, and/or installation methods and is Solely for Payment documentation. Not all requirements are referenced on this document. * FAA commissioning coordination, any adjustments required by flight checks, and testing are covered by retention and should not be included in this Construction Quantity Verification calculation.*

BASIS OF PAYMENT

Payment for all kerf, conduit, or ductbank (except bid item ER4-5) will be made at the contract unit price per linear foot for each type and size of kerf wire way system, conduit or duct bank system completed and accepted by Contract Manager, which shall include coordination, site investigation, mobilization, demobilization, saw cutting, dewatering, excavation, trenching, shoring, utility locating, disposal, backfill with the designated material, pavement and paint restoration to match existing and As-Built requirements. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this item in accordance with the provisions and intent of the plans and specifications.

METHOD OF MEASUREMENT

PVC concrete encased conduit will be measured for payment by the linear feet of conduit installed in new or existing pavement/soil, all other appurtenance and accessories required to install a fully functional system in place, completed and accepted by the Contract Manager. Separate measurement will be made for the various different diameters of conduits.

MEASURED QUANTITIES *(Attach any additional sheets as needed or required)*

Date of Work	Location		Sheet No. (Indicate 19's or 1's side)	Quantity Installed (LF)
	To	From		
	RLL26A-29-2	05-1	E1-2.61 & E1-2.75	205
	1242	RLL30-33-2		171
	RLL26A-29-1	070-1		178
	RLL27B-29-1	070-1		178
	12122	RLL30-33-1		201
	[illegible]			

CQV

Owner Furnished Material? ☐ Yes ☐ No

SPEC REQUIREMENTS

Spec Requirements
Utility locating *Confirm issues of conflict have been addressed and meets Airports minimum depths standards of 36"in paved areas or 24"in non-paved areas, unless otherwise noted.*
Bay Mud or unstable soil (N/A if the soil is stable) *See contract document on how the issue should be addressed.*
Electrical caution tape *Install per contract documents*
Conduit termination accessories *Grommets, or grounding, etc..*
BackFill per specs and drawings. *Includes bedding material and anchoring of conduits.*
Compaction Test 1. *Subgrade and bottom of trench shall achieve a minimum of 95% compaction.* 2. *All backfill shall be compacted to the density required under Item P-152. Subgrade and bedding material shall be compacted to a minimum of 95%, unless otherwise specified under Item P-152.*
Final grade restoration including paint *Final grade material shall match surrounding grade material, unless otherwise noted.*
Survey (As-Built) *(Item is part of retention)* *Survey the location of conduits installed. Update as-built drawings and CAD as-built. Airport Surveyors will perform quality assurance survey to check Contractor's work.*

Attach ALL tests and surveys prior to payment.

Verification of Quantities are for Progress Payment Purposes Only. Inspector and/or Superintendent are verifying the quantity as to the observed quantity installed.

VERIFIED BY

Contractor Signature: _____ **Date:** 6/14/14

Print Name: Jeffrey Locsin

SFO Inspector Signature: _____ **Date:** 6/14/14

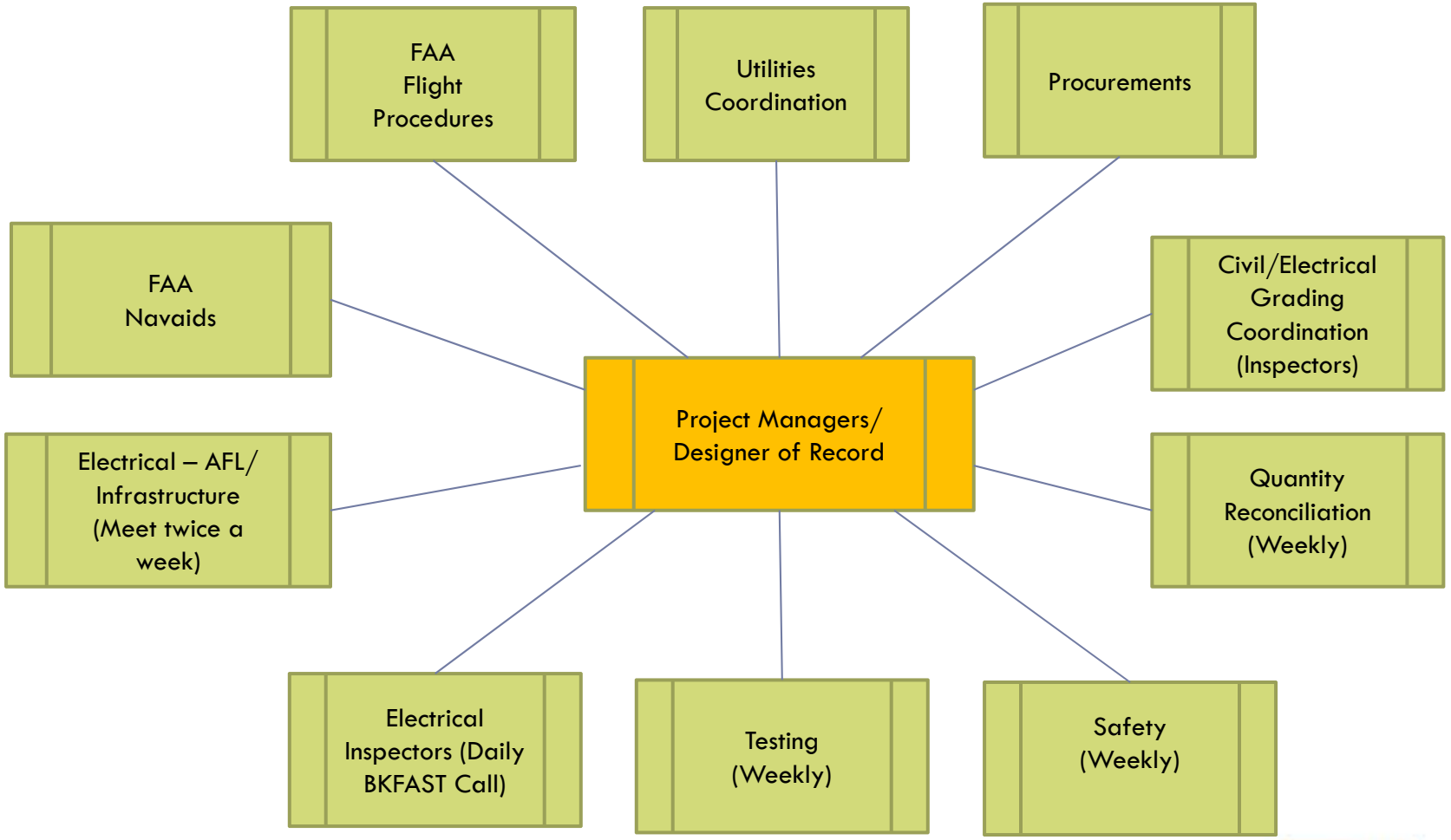
Print Name: Kevin Korcok

Inspection

RSA	Fixture 1
= Correct as required	
þ= Satisfactory (enter initials)	
Can free of debris / water	
Brick in place	
Conduit 1-1/2" max into can	
Bell end on conduit	
Transformer wattage	
Circuit tags in place	
Fixture I. D. tag in place	
Ground wire connected	
Heat shrink installed	
Fixture leads o.k.	
Check for bare wires	
O-rings / gaskets o.k.	
Check proper bolt length	
Check for broken bolts	
Lock washer position	
Anti-seize used	
All bolts torqued	
Elevated fixture; level?	
Elevated fixture clamps	
Fixture elevation o.k.	
Fixture centered in core	
P=606	
Lenses Clean	
Energize circuit	

- 4 Electrical Inspectors for North/South field.
- One dedicated to work outside the fence.
- FAA Additional inspectors.
- Chief Electrical Inspector was involved in developing drawings and quantities and checklist.
- Inspector required to provide checklist for each light fixture.
- 4 Inspectors and 100 electricians – Need to prioritize and let the client know.

FAST Action Teams - *Inspection*



Airfield Lighting Challenges

Lalesh Sharma

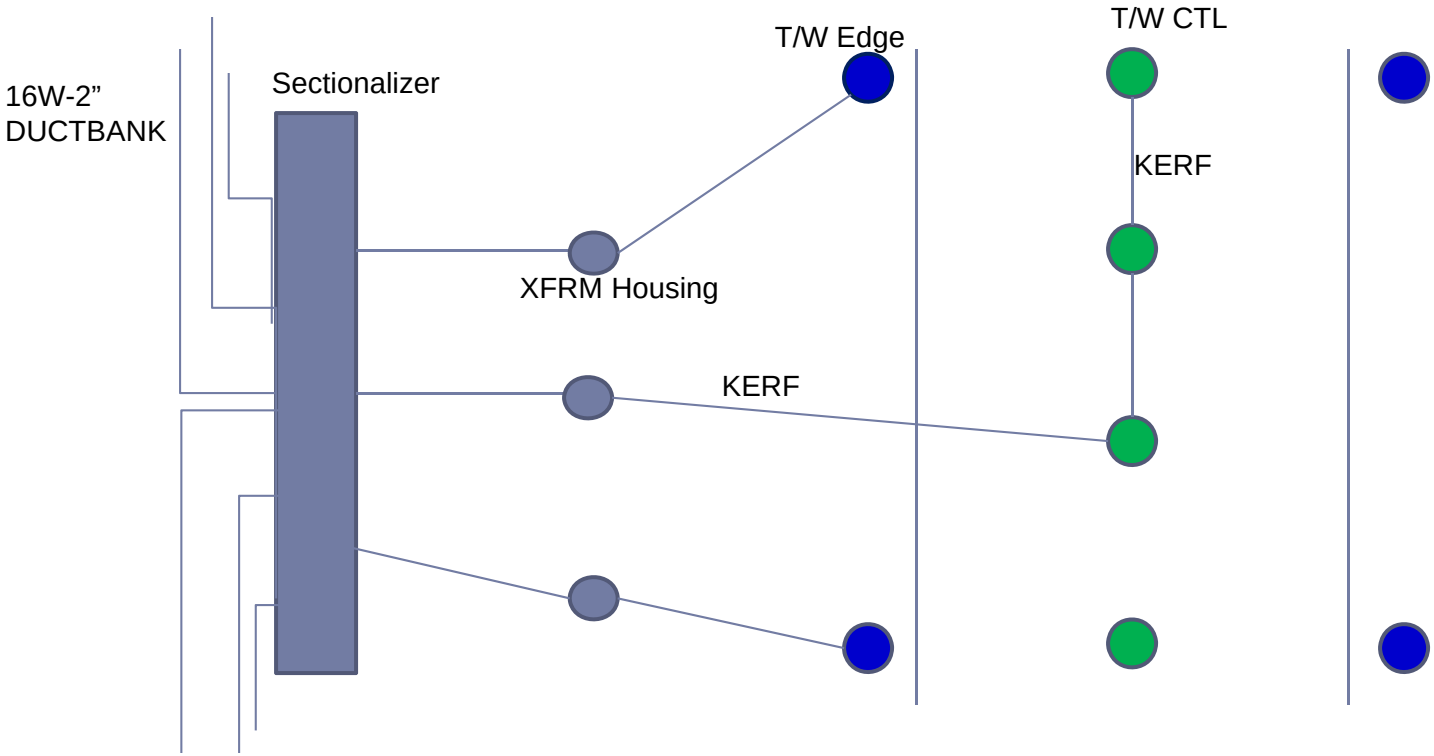
Fun Facts

- Number of Sectionalizers = 30
- Length of 2” Primary Cable Conduit = 179,000’
- Secondary Conduit (various sizes) = 60,000’
- Taxiway Kerf = 52,000’
- Length of Primary Cable = 950,000’
- Length of Secondary Cable = 320,000’

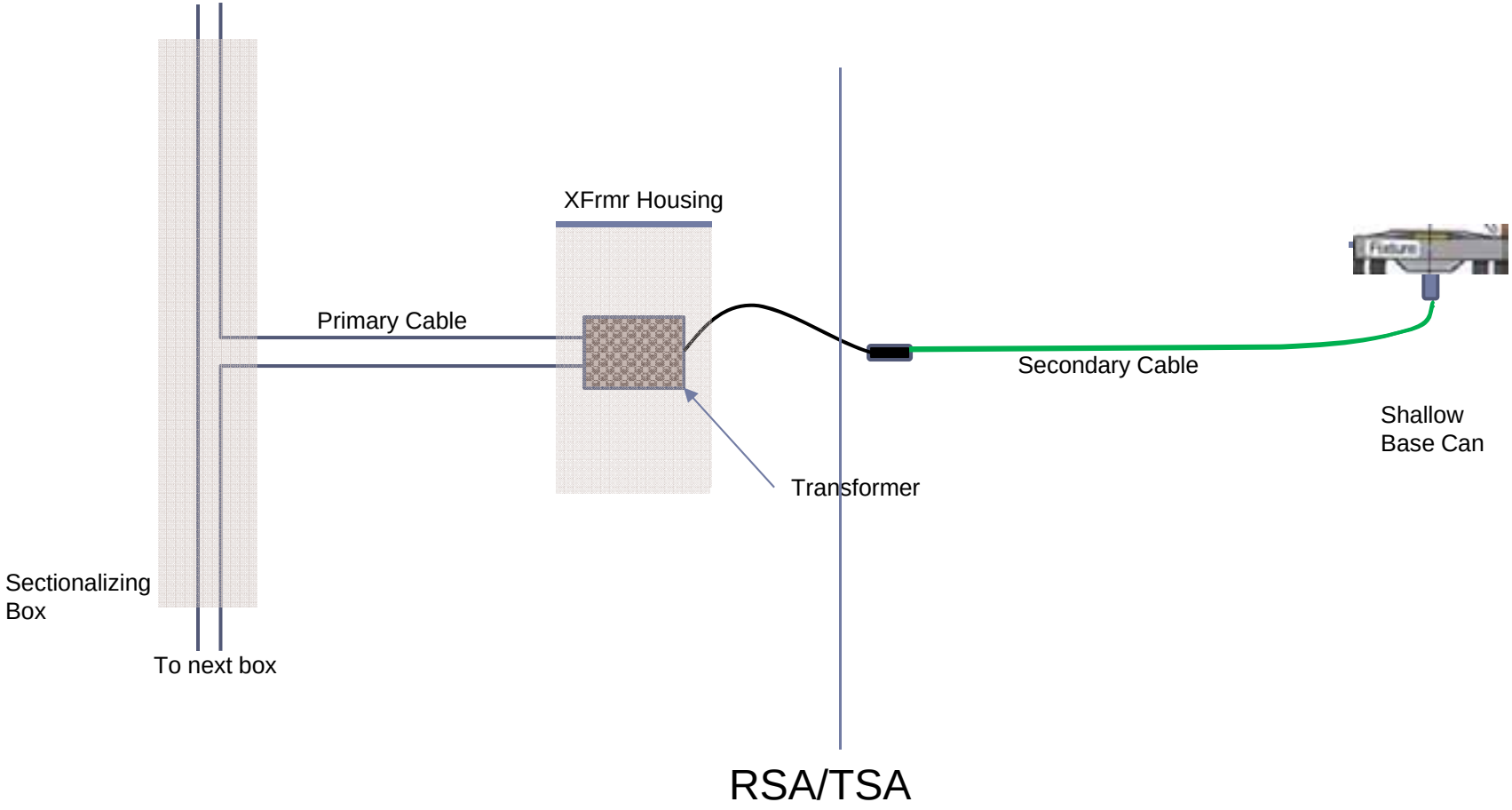
Airfield Lighting – Use of Sectionalizers

San Francisco International Airport

- SFO uses complex system of Sectionaliers
  - To improve safety: Uses individual conduits for each circuit => easy lock out tag out
  - Do not need confined space permit.
  - Isolate individual circuits. Failures in one circuit does not take down the system.
  - Transformers and primary cable installed outside of RSA/TSA. Can troubleshoot primary with no closures.
  - Kerf installed for t/w centerline lights
  - Pavements in SFO sink and need to be rehabilitated frequently 3-4 years.



Single Line


XFrmr Housing
Primary Cable
Secondary Cable
Shallow
Base Can
Transformer
Sectionalizing
Box
To next box
RSA/TSA

AFL - Sectionalizers

- Coordinate grading closely with civil due to length of box. Provide exact heights/elevations.
- Provide detailed circuit line diagrams (fixture by fixture) to allow for easy troubleshooting.
- Every box or junction can tagged with xfrmr #, circuit number, for easy tracking.

Ductbank

- Red concrete allowed us to understand what was new vs. old

Duct bank installation

Transformer Housing Plaza

Sectionalizer cable installation

Sectionalizer

Completed sectionalizer

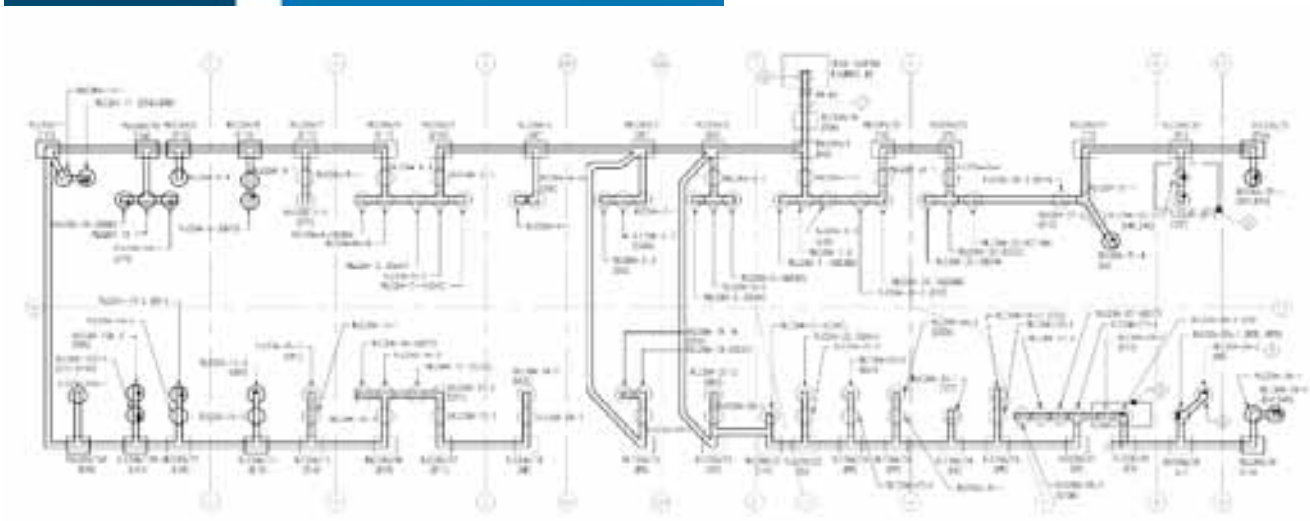
T/W CTL Kerf

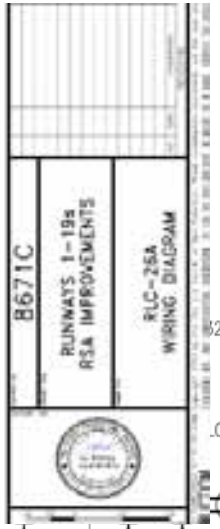
Taxiway Centerline Light installation

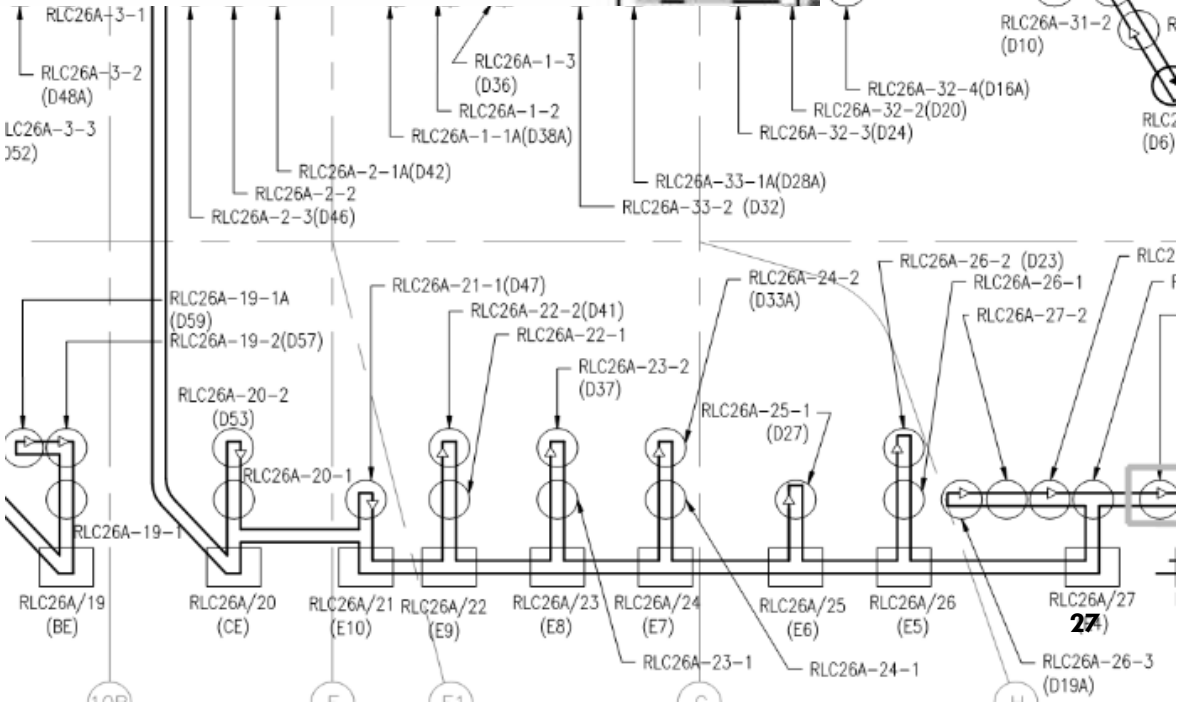
Taxiway Centerline light Kerf installation

Typical T/W Kerf Installation

AFL Single LIne







Installing Temporary AOA Fence

Relight Runways as Taxiways

- Installed solar powered edge lights with fog kit. Worked very well with no complaints from operations or tower.
- Shut off taxiway centerline lights into intersections going into and out of areas not being used.
- Lighted Runway 1-19s intersection with 10-28s as a guard light hold bar with Elevated L-804. Installed on IRGL circuit.
- Rerouted power cable along fence line.

Temp barrier fence and conduit

Lighting Upgrades

- L-852K Fixtures – used on all taxiway ctl including SMCGS -> so far very good feedback.
- T/W CTL LED.
  - lights deemed too bright on Step 1 of a Step 3.
  - Implemented 5 step CCRs for all centerline lights.
  - operating at step 2 nominally.
- LED R/W CTL and TDZ.
  - Feedback has been positive
- Reimbursement
  - All LED R/W and T/W LED lights and signs were considered reimbursable except for LED Obstruction lights.

Taxiway Centerline lights

Precast Signs

- Work inside the RSA had to be performed under quick runway closures.
- Wherever possible used precast signs for both airfield guidance signs and sectionalizers.

Ground rod installation for precast sign pad

Preprocurement

- Risk – equipment is faulty and can't be installed in time.
- 5 Separate packages: (Sectionalizers, Light Fixtures, Base Cans, Transformers, PAPI, MALSR,REILS, Sophisticated cable)
- Supplied "breakage" fixtures, base cans, transformers, solar lights.
- Created Testing Plan by SFO:
  - 50KVA, 25KVA Transformers – testing agency performed Factory style on-site testing to confirm Voltage and impedance.
  - AFL Lights – Procurement specification allowed airport mechanism to test fixtures to ETL standards after on-site.
  - Base Cans – Asked Mfg. to perform testing on select randomn base cans.

Lessons Learned

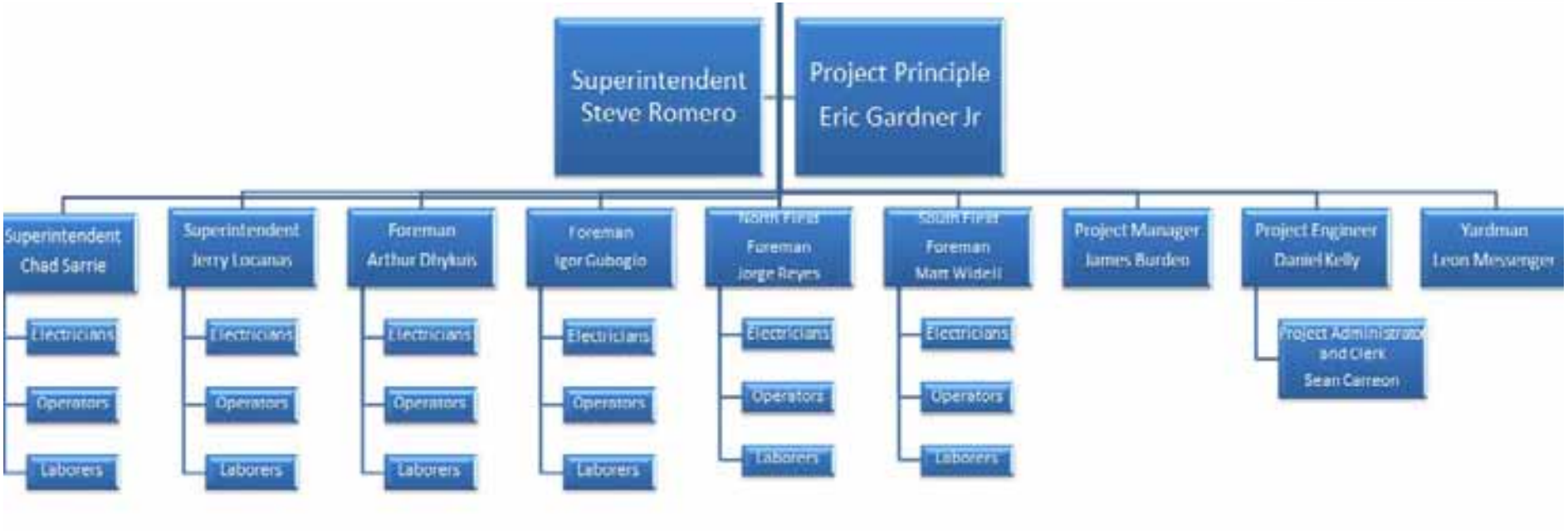
- Original installation had RGS PVC Coated Pipe. We experienced corrosion on existing pipe and couldn't loosen cable. → Went to schedule 80 pipe. Used Cable free product with a lot of success.
- Special coordination required with civil and electrical to accommodate grading changes as sectionalizers were over 30' long.
- Pre-cast sign pad and pre-cast transformer housing allowed cost and time saving which result is faster production during construction.
- Coordination and staffing with Airfield Operations was key to meet the early opening.

Contractor Challenges:

Eric Gardner, Jr.

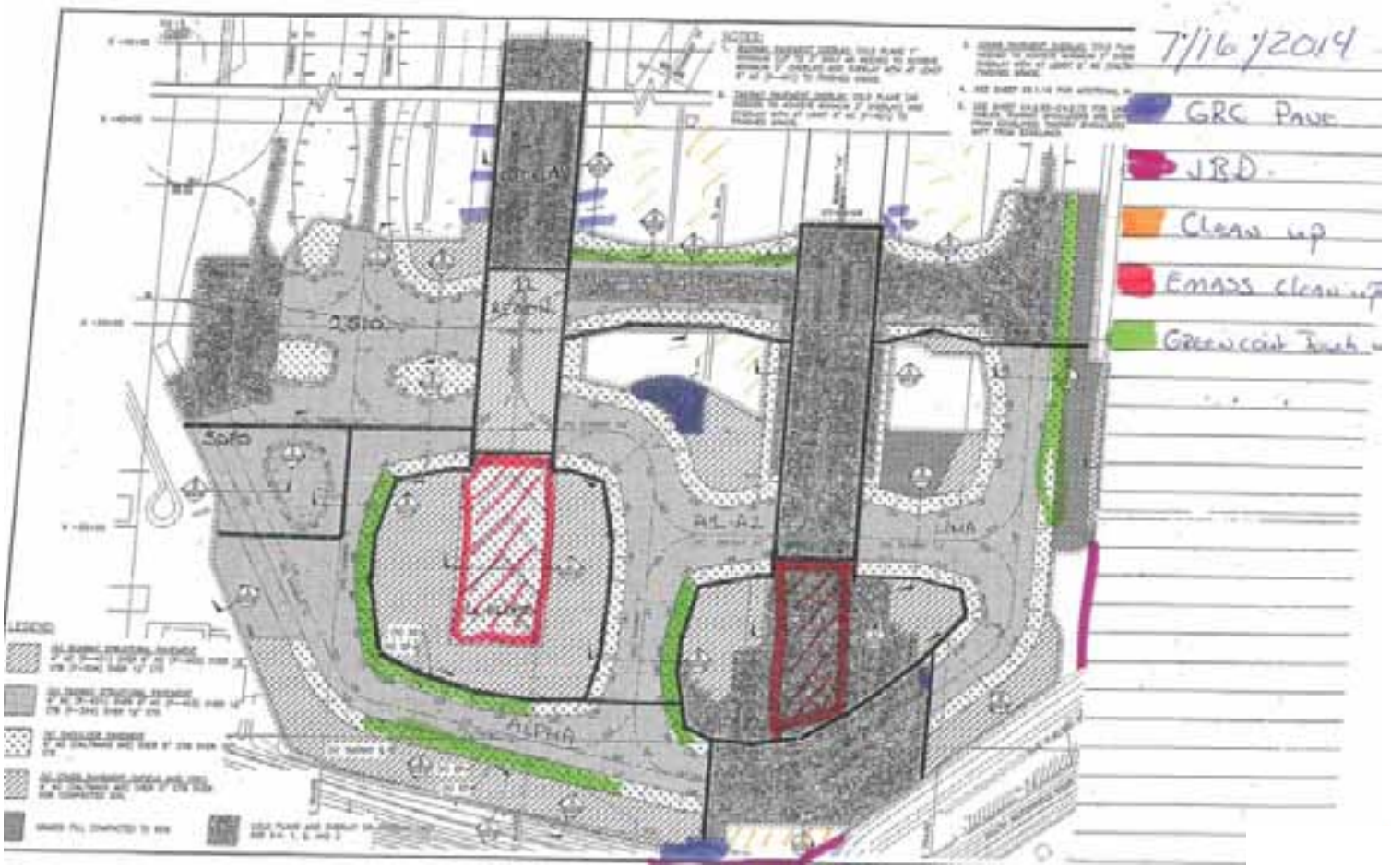
Construction Challenges

- Org Chart



Construction Challenges

- Challenge: Coordination between Civil and Electrical
- Solution: Area map highlighting work to be complete.



Construction Challenges

- Challenge: Right Information to the Right Person at Right time
- Solution:

Construction Challenges

- Challenge: Logistics between North and South Field (Almost Independent Projects)
- Solution:
  - Centrally located warehouse on airport property.
  - Timed turnover delivery from mfg. (ex. Sectionalizers & handhole. For example; sectionalizers and handholes delivered exactly when needed.
  - One person responsible for all material (dedicated position)
  - One person on both North and South Side to handhole/track equipment.

Construction Challenges

- Challenge: Work in Center Area (Cross) –
  - RWSL work. 7 taxiways to do work and pavement
  - Cable pulling (750,000 feet) in existing conduit. Perfect storm for a challenge – 90 degree standard radius bends & old PVC RGS Coated Conduit in corrosive environment
- Solution:
  - Dedicated Civil coordinator.
  - Existing cable would not come out.
    - Cable free
    - Reel Up Trailer with breakaway.

Construction Challenges

- Temporary Electrical Installation in one 24 hour switchover night.
- Solution:
  - 75 People during this phase.
  - Solar Powered Edge Lights.
  - Elevated Guard Lights
  - Power Reroute on the fence

Temp barrier fence and conduit

NAVAID INFRASTRUCTURE

AND

WRAP UP

DORON LEAN

New Criteria for Frangibility

- FAA has closed the gap on fixed by function inside the RSA and ROFA.
- Solutions:
  - Aircraft Rate as much as possible.
  - Frangibilize items outside the RSA that make sense -> analyze for structure stability.
    - This is a structural problem that needs to be analyzed on an airport by airport basis.
  - Ex. Blast Fence, Equipment Rack – LIR Poles, RVR racks, etc…

Table 6-1. Fixed-by-function designation for Navigation Aid (NAVAID) and Air Traffic Control (ATC) facilities for Runway Safety Area (RSA) and Runway Object Free Area (ROFA)

NAVAID	Fixed-By-Function		
	In RSA	In ROFA	Associated Equipment
Airport Beacon	No	No	N/A
ALS	Yes	Yes	No [1]
ASDE-X	No	No	N/A
ASOS, AWOS	No	No	N/A
ASR	No	No	N/A
ATCT	No	No	N/A
DME	No	No	No
GS	No [2]	No [2, 3]	No
IM	Yes	Yes	Yes
LDIN	Yes	Yes	No [1]
LOC	No	No	No
LLWAS	No	No	No
MM	No	No	No
NDB	No	No	N/A
OM	No	No	No
PRM	No	No	No
REIL	Yes	Yes	No [1]
Runway Lights and Signs	Yes	Yes	No
RTR	No	No	No
RVR	No	Yes	Yes
RWSL	Yes	Yes	No
Taxiway Lights and Signs	Yes	Yes	No
VOR/TACAN/VORTAC	No	No	N/A
PAPI & VASI	Yes	Yes	No
WAAS	No	No	No
WCAM	No	No	No
WEF	No	No	No
Wind Cone	No	No	No

Notes:

1. Flasher light power units (Individual Control Cabinets) are fixed-by-function.
2. End Fire glideslopes are fixed-by-function in the RSA/ROFA.
3. Allowing a GS within ROFA due to a physical constraint should be evaluated on a case-by-case basis.

b. Frangibility. NAVAID objects located within operational areas on the airport are generally mounted with frangible couplings, with the point of frangibility no higher than 3 inches

Example: REILS, RVR

- Example: RVR Power and Equipment Rack shall be outside the ROFA.
- Other Power and Equipment Rack shall be outside ROFA

REIL Power and control rack

MALSF - Challenges

- Shift 200' required construction
- Two stations in the EMAS. Provide a maintainable system that meets meets frangible requirements while allowing FAA to re-enter the system. Especially important in corrosive environment.
- Create a pier ductbank system that responds well to SFO's harsh corrosive environment on the

Light Stations

MALSF Station 4

MALSF Station 4

MALSF Sta 2 frangible coup

Station 2 and 4

MALSF Sta 4

MALSF Station 2

MALSF Wiring

Frangible Control Box

MALSF Distribution panel

MALSF Dist Panel

Coordinating grading and Navaids

- Assigned an inspector to meet with Civil Engineer/General Contractor to review grades.
- Inspection team had independent surveyor.
- Electrical performed ahead of Civil Grading.

Paving around Glideslope

Keeping up with the Grading

19L Localizer Shelter

Pier Ductbank Installation

- MALSR on the water exposed to Hold/Cold and large swings in temperature.
- MALSR pier conduit exposed to strong sea-salt and winds.
- Existing RGS corroded and broke apart.
- Created (FAA) a system that (a) sun resistant, and (b) bends/flexes with temp. and movement.
  - HDPE sun resistant pipe
  - Adaptors that provide 14" of movement on both ends of the pipe.
  - Strapping larger than conduit allowed for movement and bending.

Additional RNAV Procedures as Risk Management

- Tie in between RNAV Procedures and Certain Lighting
- Decouple the ILS flight-checking from opening runway with developing approaches ahead of time.
- Lean developed its own procedure for FAA implementation.

Procedure	Navaids	Ceiling	RVR
S-ILS 19L	With MALSF	300’	5000’
	Without MALSF	300’	6000
RNAV - LPV	With MALSF	293’	3000’
	Without MALSF	293’	6000’
	Requires PAPI	“	“
	Requires Lighting of Seawall*	“	“

Seawall Lights

- Installed L-810 OB Lights on seawall inside the POFZ and "W" Obstruction lights.
- Ex. Lighting impacting Flight Performance.
- LED Implementation:
  - ADO would not fund LED Lighting. SFO made an environment decision by self-funding the LED light fixtures.
  - ADO would not allow LED on sea-wall.
    - LED does not have heat signature.
    - Therefore Seawall is not a lit obstruction.
    - No operations.

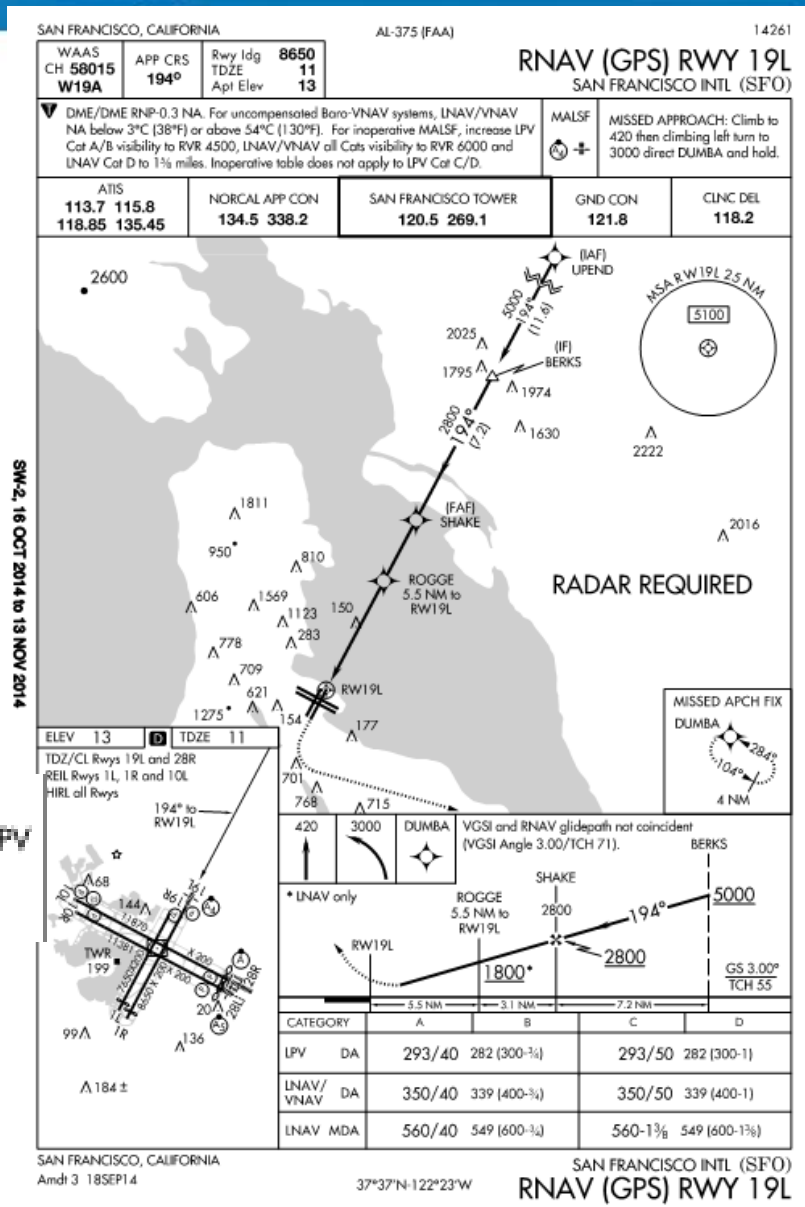
Courtesy IESALC, Captain Bob Moreau

(L) Indicates LED fixture
Any fixture listed above that uses a LED lighting source may not be compatible with Enhanced Flight Vision Systems that use IR energy emissions for imaging.

Additional RNAV Procedures as Risk Management

San Francisco International Airport

- September 2012 – Risk Matrix (Understand effectiveness of RNAV approach only)
- October 2012 – FAA Starts Flight Procedure Development.
- June 2015 – Complete procedure. Takes nearly 3 years to get it done.



DME/DME RNP-0.3 NA. For uncompensated Baro-VNAV systems, LNAV/VNAV NA below 3°C (38°F) or above 54°C (130°F). For inoperative MALSF, increase LPV Cat A/B visibility to RVR 4500, LNAV/VNAV all Cats visibility to RVR 6000 and LNAV Cat D to 1⅜ miles. Inoperative table does not apply to LPV Cat C/D.

Phasing

- May 16, 2014 – Paint new thresholds and Flightcheck RNAV Procedures – Prior to construction.
- July 24, 2014 – Publish RNAV procedures but keep runways closed.
- August 10, 2014 – Open Runways (not a publication date so can't operate ILS but you can activate RNAV)
  - Operate departures and RNAV landings
- September 18, 2014 – Publish ILS Procedure
- Biggest advantage – didn't have to wait for flightcheck.

Conclusions

- Project delivered ahead of schedule and under budget.
- Positive work-relationship between stakeholders.
- Mitigated and managed risk.
- Got the job Done.
- Had fun.