SoSECIE Webinar

Welcome to the
2022 System of Systems Engineering Collaborators Information Exchange (SoSECIE)

We will start at 11AM Eastern Time

You can download today's presentation from the SoSECIE Website:

https://mitre.tahoe.appsembler.com/blog

To add/remove yourself from the email list or suggest a future topic or speaker, send an email to sosecie@mitre.org

NDIA System of Systems SE Committee

- **Mission**
  - To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
  - To identify successful strategies for applying systems engineering principles to systems engineering of SoS
- **Operating Practices**
  - Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August

NDIA SE Division SoS Committee Industry Chairs:
Mr. Rick Poel, Boeing
Ms. Jennie Horne, Raytheon
OSD Liaison:
Dr. Judith Dahmann, MITRE

Simple Rules of Engagement

- **I have muted all participant lines for this introduction and the briefing.**
- **If you need to contact me during the briefing, send me an e-mail at sosecie@mitre.org.**
- **Download the presentation so you can follow along on your own**
- **We will hold all questions until the end:**
  - **I will start with questions submitted online via the CHAT window in Teams.**
  - **I will then take questions via telephone; State your name, organization, and question clearly.**
- **If a question requires more discussion, the speaker(s) contact info is in the brief.**

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2022 System of Systems Engineering Collaborators Information Exchange Webinars

Sponsored by MITRE and NDIA SE Division

September 20, 2022

Towards Mission Engineering in a MOSAIC Warfare Context using Explainable AI

Daniel DeLaurentis

September 27, 2022

Multi-Disciplinary Insights into Measurement and Assessment for SoS

Jaci Pratt and Stephen Cook

October 18, 2022

Framework for Complex SoS Emergent Behavior Evolution Using Deep Reinforcement Learning

Ramakrishnan Raman and Anitha Murugesan

https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

32nd Annual INCOSE international symposium

hybrid event

Detroit, MI, USA
June 25 - 30, 2022

June 30, 2022: 10:45-11:25 EDT (Track 6, Digital Engineering, Session 11.6.2)

Case Study: Using Digital Threads in a large System of Systems (SoS) for System Certification

Oliver Hoehne, PMP, CSEP, CSM
Technical Fellow, Systems Engineering
WSP USA
oliver.hoehne@wsp.com

AGENDA

- **Introduction**
  - Brief System of Systems (SoS) Overview
  - California High-Speed Rail System (CHSRS) Program
  - Use of Digital Threads in the CHSRS Program
- **SoSE Challenges Faced**
  - Systems Engineering Challenges
  - SoS Engineering Challenges
- **SoSE Activities Performed**
  - Certification Strategy
  - Step by Step Process Description
- **Summary, Achieved Outcomes & Conclusion**

INTRODUCTION: SYSTEM OF SYSTEMS

SoS DEFINITION & CHARACTERISTICS

ISO/IEC/IEEE 15288, 2015, ANNEX G

ISO/IEC/IEEE 15288:2015(E)

Annex G
(informative)

Application of system life cycle processes to a system of systems

G.1 Introduction

A system of systems (SoS) is a system-of-interest (SOI) whose elements are themselves systems. A SoS brings together a set of systems for a task that none of the systems can accomplish on its own. Each constituent system keeps its own management, goals, and resources while coordinating within the SoS and adapting to meet SoS goals. In the context of terminology discussed in subclause 5.2.3 (as shown in Figure 3), the composite set of systems including the original SOI, enabling systems and interacting systems, together constitute an SoS. Where there are concerns that affect the composite set, the system of systems becomes the SOI, which is considered to satisfy some business or mission objective that cannot be satisfied by the individual constituent systems, or to understand emergent behavior of the combination.

This annex addresses the application of system life cycle processes to such SoS. It describes general characteristics, the common types of SoS, and the implications throughout the life cycle.

G.2 SoS characteristics and types

SoS are characterized by managerial and operational independence of the constituent systems, which in many cases were developed and continue to support originally identified users concurrently with users of the SoS. In other contexts, each constituent system itself is a SOI; its existence often predates the SoS, while its characteristics were originally engineered to meet the needs of their initial users. As constituents of the SoS, their consideration is expanded to encompass the larger needs of the SoS. This implies added complexity particularly when the systems continue to evolve independently of the SoS. The constituent systems also typically retain their original stakeholders and governance mechanisms, which limits alternatives to address the needs of the SoS.

SoS have been characterized into four types based on the governance relationships between the constituent systems and the SoS (Figure G.1). The strongest governance relations apply to directed system of systems, where the SoS organization has authority over the constituent systems despite the fact that the constituent systems may not have originally been engineered to support the SoS. Somewhat less control is afforded for acknowledged SoS, where allocated authority between the constituent systems and the systems of systems has an impact on application of some of the systems engineering processes. In collaborative SoS, which lack system of systems authorities, application of systems engineering depends on cooperation among the constituent systems. Virtual systems of systems are largely self organizing and offer much more limited opportunity for systems engineering of the SoS.

Emergence is a key characteristic of SoS – the unanticipated effects at the systems of systems level attributed to the complex interaction dynamics of the constituent systems. In SoS, constituent systems are intentionally considered in their combination, so as to obtain and analyze outcomes not possible to obtain with the systems alone. The complexity of the constituent systems and the fact they may have been designed without regard to their role in the SoS, can result in new, unexpected behaviors. Identifying and addressing unanticipated emergent results is a particular challenge in engineering SoS.

Definition: A system of systems (SoS) is a system-of-interest (SOI) whose elements are themselves systems.

A SoS brings together a set of systems for a task that none of the systems can accomplish on its own.

Each constituent system (CS) retains its own management, goals, and resources while coordinating within the SoS and adapting to meet SoS goals.

SoS Characteristics: SoS are characterized by managerial and operational independence of the constituent systems, which in many cases were developed and continue to support originally identified users of the constituent concurrently with users of the overall SoS.

INTRODUCTION: SYSTEM OF SYSTEMS

SoS EMERGENCE

ISO/IEC/IEEE 15288, 2015, ANNEX G

ISO/IEC/IEEE 15288:2015(E)

Annex G
(informative)

Application of system life cycle processes to a system of systems

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INTRODUCTION: SYSTEM OF SYSTEMS

INCOSE SOS PRIMER – FURTHER READING

INCOSE

INCOSE Systems of Systems Primer

INCOSE-TP-2018-003-

Systems tend to…	Syste
Have a clear set of stakeholders	Have m and po
Have clear objectives and purpose	Have m objecti
Have a clear management structure and clear accountabilities	Have d clear a
Have clear operational priorities, with escalation to resolve priorities	Have m operati routes
Have a single lifecycle	Have m implem
Have clear ownership with the ability to move resources between elements	Have m resourc

Types of SoS

A taxonomy has evolved (proposed by Maier 1998, and extende been widely used to categorise SoS into four different types bas noting that SoS are often complex, and may be classed different are viewed at, or their current operating mode at any one time.

Directed SoS are built and managed to fulfill sp to ensure goals are met. Although constituent s they accept that their normal operational mode i can be found in metropolitan transportation syst services may collaborate to deliver metro servic direction in order to participate.

Acknowledged SoS have objectives recognize manager, and dedicated SoS resources. Consti objectives, funding, development and sustainme are based on agreed collaboration. Air traffic co and safe airspaces globally all recognise their s adhere to regulations and protocols.

Collaborative SoS comprise constituent system some central purposes, which can evolve based An electrical grid is an example. Autonomous co electricity to consumers. Unlike an acknowledge Constituent systems adhere to standards and re roles and working practices.

Virtual SoS have no central authority, nor an ex SoS can exhibit large-scale emergent behavior, The internet is an example. The Internet Engine standards and protocols. Independent service pr products. No management or governance is eit there is no central purpose for all parties.

INCOSE Systems of Systems Primer

SoS Authority

How do we handle collaboration and agreement when there is no overall director? Effective patterns for collaboration are needed, but are often difficult to recognise or establish. The defense sector tackles this with a focus on finding ways to balance the values & needs of constituent systems with those of the SoS. Other application domains tackle this through incentivizing constituent systems, creating an environment where they can meet their own goals whilst collaborating to support SoS goals.

SoS Principles

What are the key SoS thinking principles? Surveys of SoS practitioners have identified areas where basic principles are lacking. These include: lack of formalized SoS processes; lack of SoS success stories; and information about workflows. Much more research on SoS working contexts is needed to develop a body of recognized best practice.

Leadership

What are the roles & characteristics of effective SoS leaders? The increasingly complex collection of independent systems in an SoS typically straddles disciplines, application domains, organizations and even national boundaries, and each constituent system is capable of following their own interests and agenda. As a result, effective means of leadership are important. Structure and directorship usually found in SE projects is often absent for SoS, and other methods are needed to ensure coherence and direction.

Constituent Systems

How to integrate constituent systems? Each constituent system has its own agenda and goals, and can act autonomously. Some may be legacy systems not designed for SoS contexts, not easily adapted, resulting in interoperability challenges. Operating an SoS means finding means to coordinate, incentivize and manage multiple separate constituent systems, with separate working cultures, schedules, processes and working practices, as well as coping with technical challenges such as communications and data exchange. Mismatched assumptions and expectations are a real risk.

INCOSE Systems of Systems Primer INCOSE-TP-2018-003-01.0

SoS Pain Points

What does a systems engineer need to know about SoS?

Many existing systems do play a role in an SoS, whether they are explicitly aware of this or not. Working in an SoS context brings a number of challenges, and it can help to be aware of these. Surveys conducted by the INCOSE SoS Working Group have identified "pain points" which are particularly associated with SoS by practising systems engineers (summarized by Judith Dahmann 2014).

[1] COMPASS project: http://thecompassclub.org/
[2] DANSE project: http://danse-ip.eu/home/
[3] INTO-CPS project: http://projects.au.dk

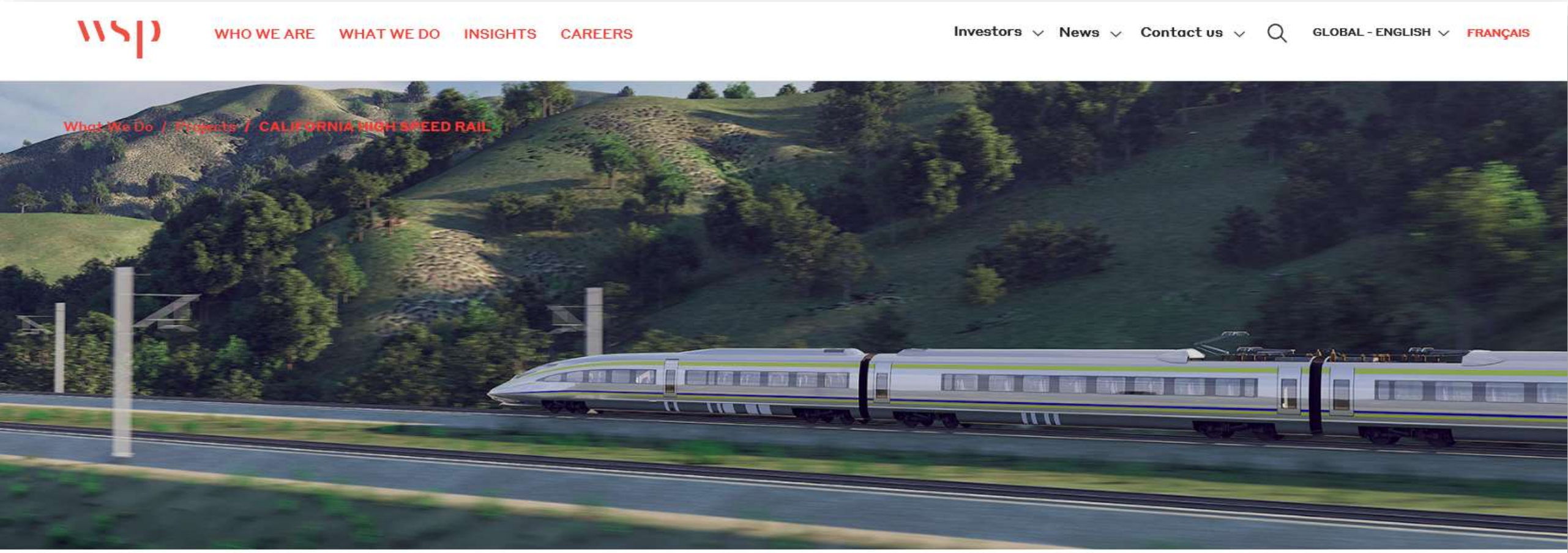
Autonomy, Interdependence & Emergence

can system engineering address the complexities
oS inter-dependencies and emergent behaviors?
dent, uncoordinated evolution of constituent systems
unanticipated emergent effects at the SoS level, often
ervable until the SoS is simulated or tested. Complex
endencies are common between constituent systems
rent stages of maturity, often not well understood or
nted. The scale, diversity & independence in an SoS
s it difficult to produce models that can accurately
t SoS-level performance. Recent work has begun
esearch SoS and emergence, SoS uncertainty &
mplexity, and modelling & simulation – see, for example,
[1, 2, 3].

INCOSE-TP-2018-003-01.0

California High-Speed Rail System (CHSRS)

Brief Introduction

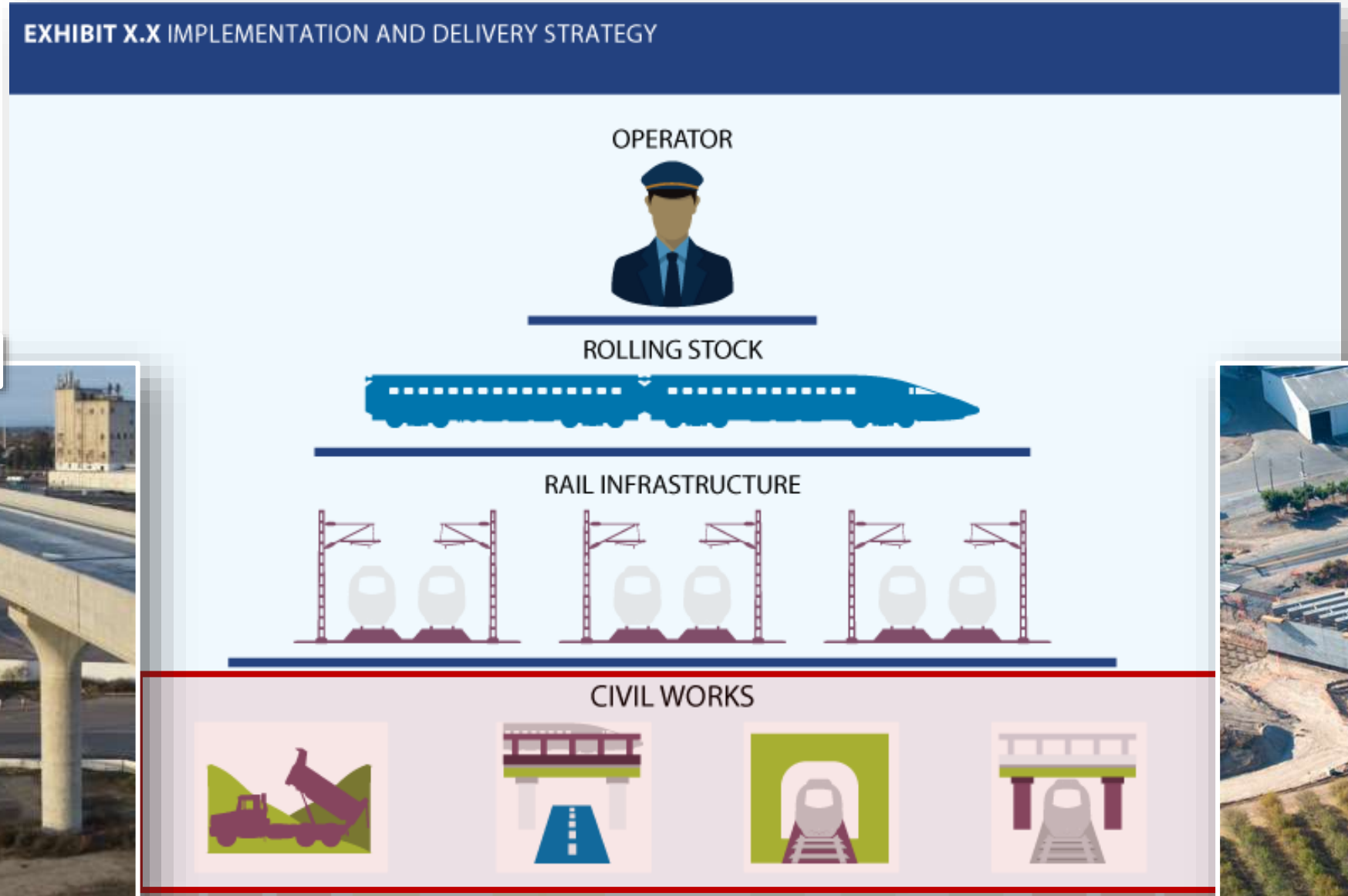


Source: https://www.wsp.com/en-GL/projects/california-high-speed-rail

CALIFORNIA HIGH SPEED RAIL

California High-Speed Rail System

Procurement Strategy / Contract Packaging

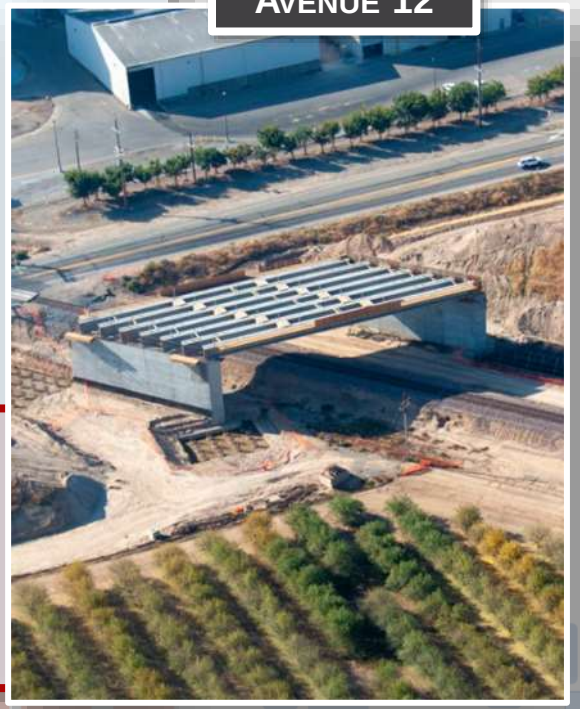


Source: 2018 Business Plan & 2019 Project Update Report to the California State Legislature.

Note: Revised Draft 2020 Business Plan available: https://hsr.ca.gov/docs/about/business_plans/2020_Business_Plan.pdf

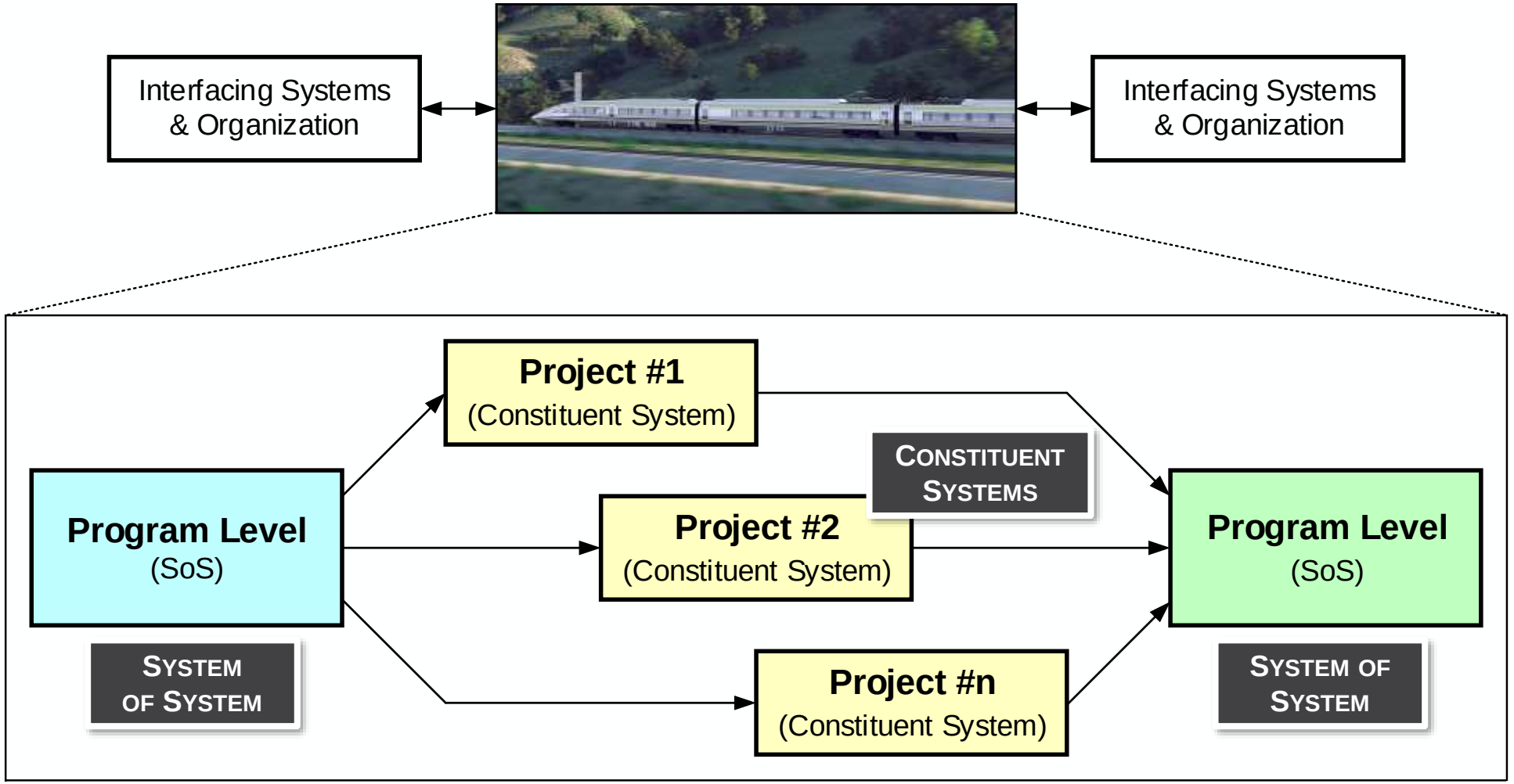
Cedar Viaduct

Avenue 12

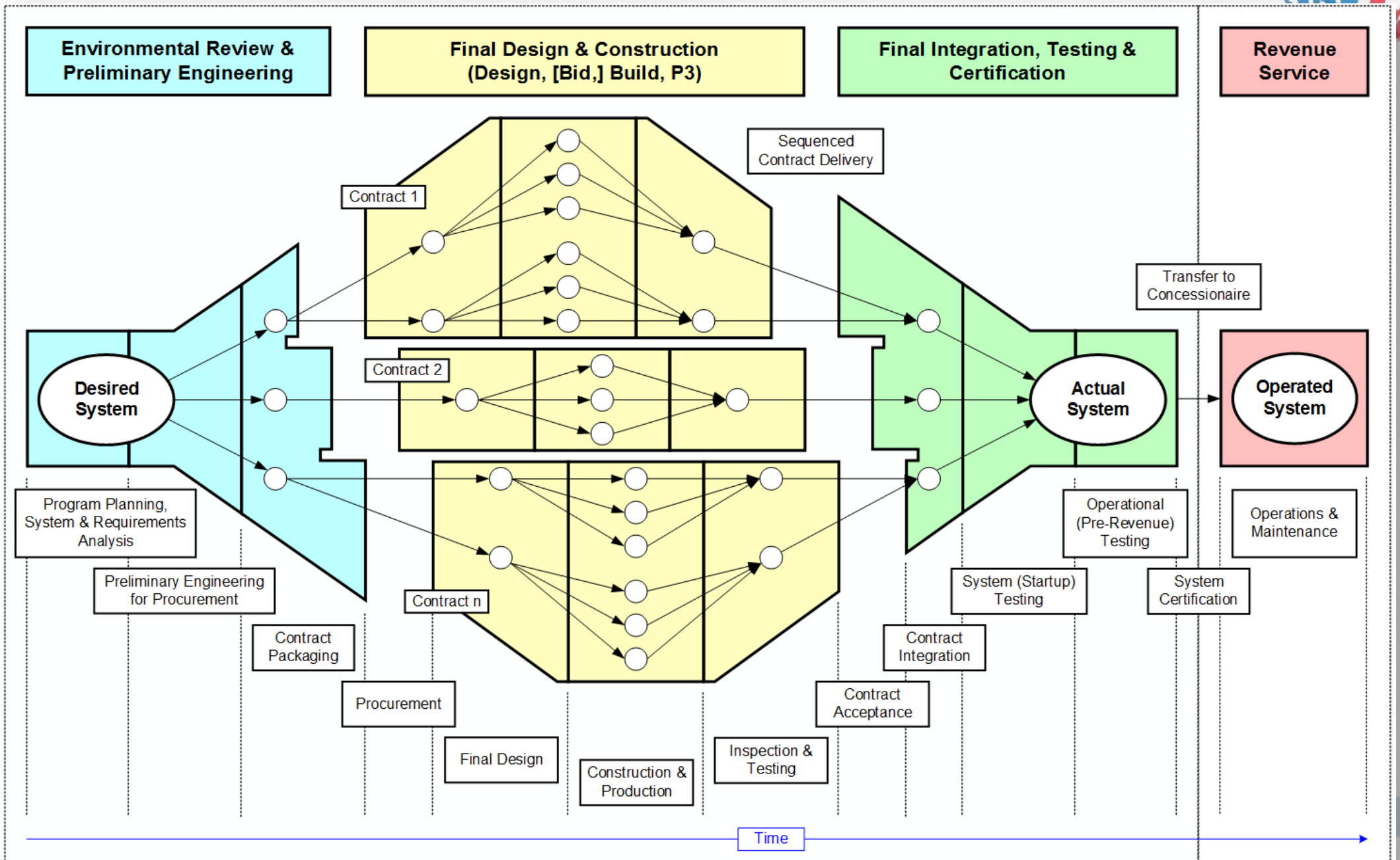


California High-Speed Rail System

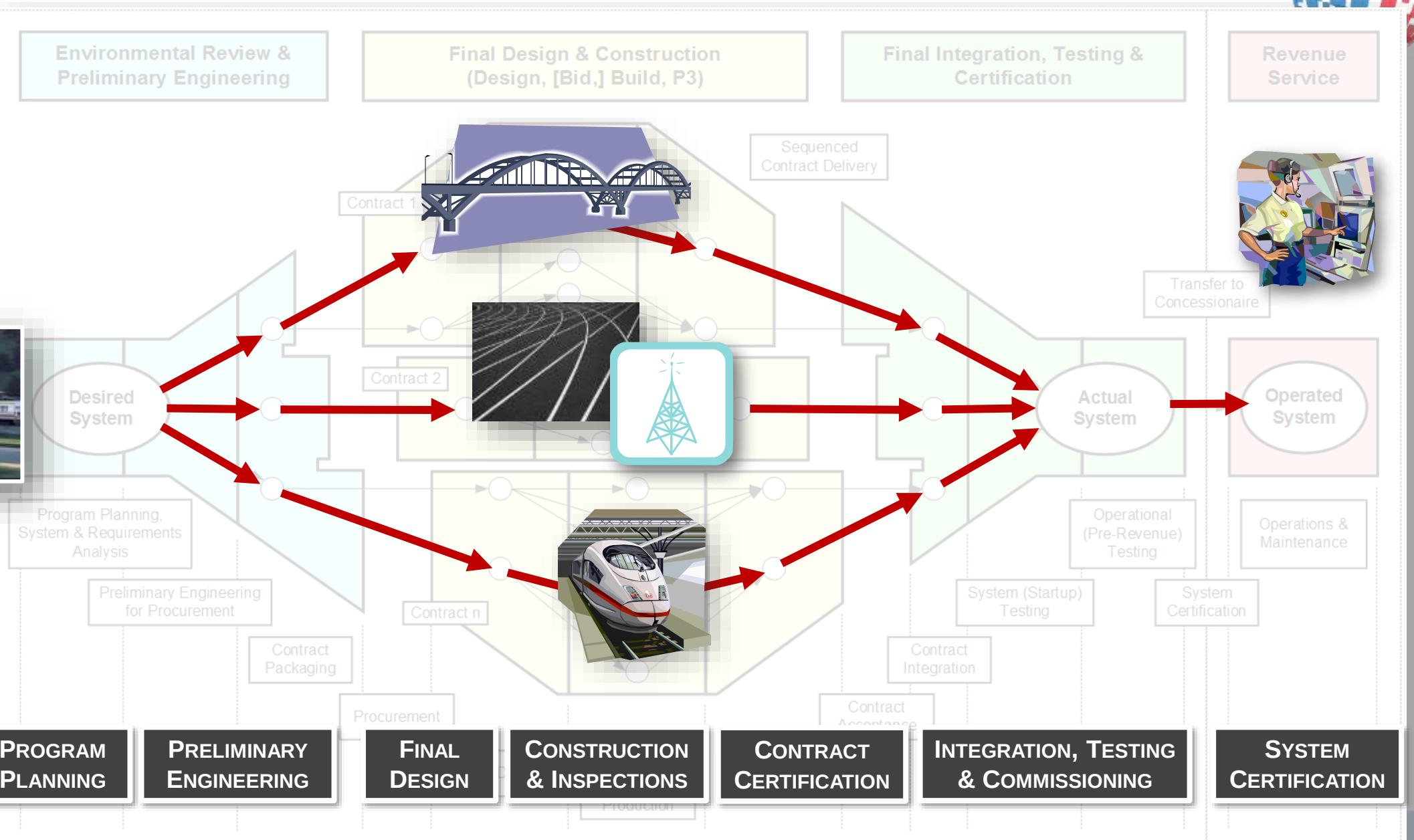
CHSRS as a SoS (Program of Projects)



CHSRS: Program Development Life Cycle



CHSRS: Use of Digital Threads (Traceability)



Program Planning	Preliminary Engineering	Final Design	Construction & Inspections	Contract Certification	Integration, Testing & Commissioning	System Certification

CHSRS: CONTRACT VS. SYSTEM CERTIFICATION

Environmental Review & Preliminary Engineering

Final Design & Construction (Design, [Bid,] Build, P3)

Final Integration, Testing & Certification

Revenue Service

Contract 1

Contract 2

Contract n

Desired System

Program Planning, System & Requirements Analysis

Preliminary Engineering for Procurement

Contract Packaging

Procurement

Contract Integration

Contract Acceptance

System Certification

Operated System

Operations & Maintenance

(Pre-Revenue)

CONTRACT CERTIFICATION
ACCEPTANCE & HANDOVER

SYSTEM CERTIFICATION
SYSTEM IS SAFE, SECURE AND READY TO OPERATE

OBJECTIVE EVIDENCE

PROGRAM PLANNING | **PRELIMINARY ENGINEERING** | **FINAL DESIGN** | **CONSTRUCTION & INSPECTIONS** | **CONTRACT CERTIFICATION** | **INTEGRATION, TESTING & COMMISSIONING** | **SYSTEM CERTIFICATION**

Time

CHSRS: Focus of this Presentation

Contract Certification
Acceptance & Handover

System Certification
System is Safe, Secure and Ready to Operate

Objective Evidence

- **Infrastructure is Ready to Operate**
  - Example **Performance** Requirements
- **Infrastructure is Safe & Secure**
  - Example **Safety** Requirement

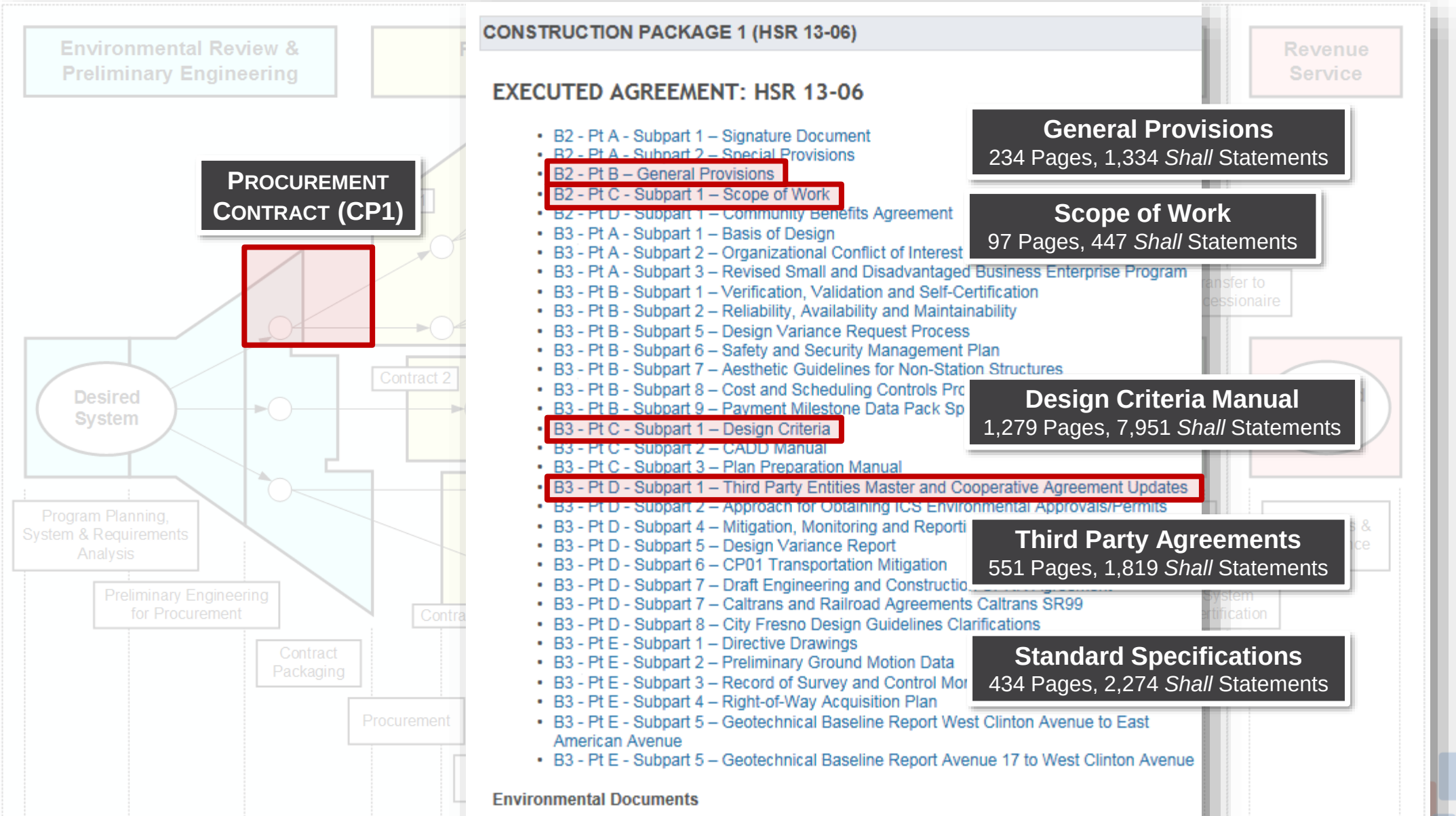
Final Design | **Construction & Inspections** | **Contract Certification**

PROGRESS

- **Introduction**
  - Brief System of Systems (SoS) Overview
  - California High-Speed Rail System (CHSRS) Program
  - Use of Digital Threads in the CHSRS Program
- **SoSE Challenges Faced**
  - Systems Engineering Challenges
  - SoS Engineering Challenges
- **SoSE Activities Performed**
  - Certification Strategy
  - Step by Step Process Description
- **Summary, Achieved Outcomes & Conclusion**

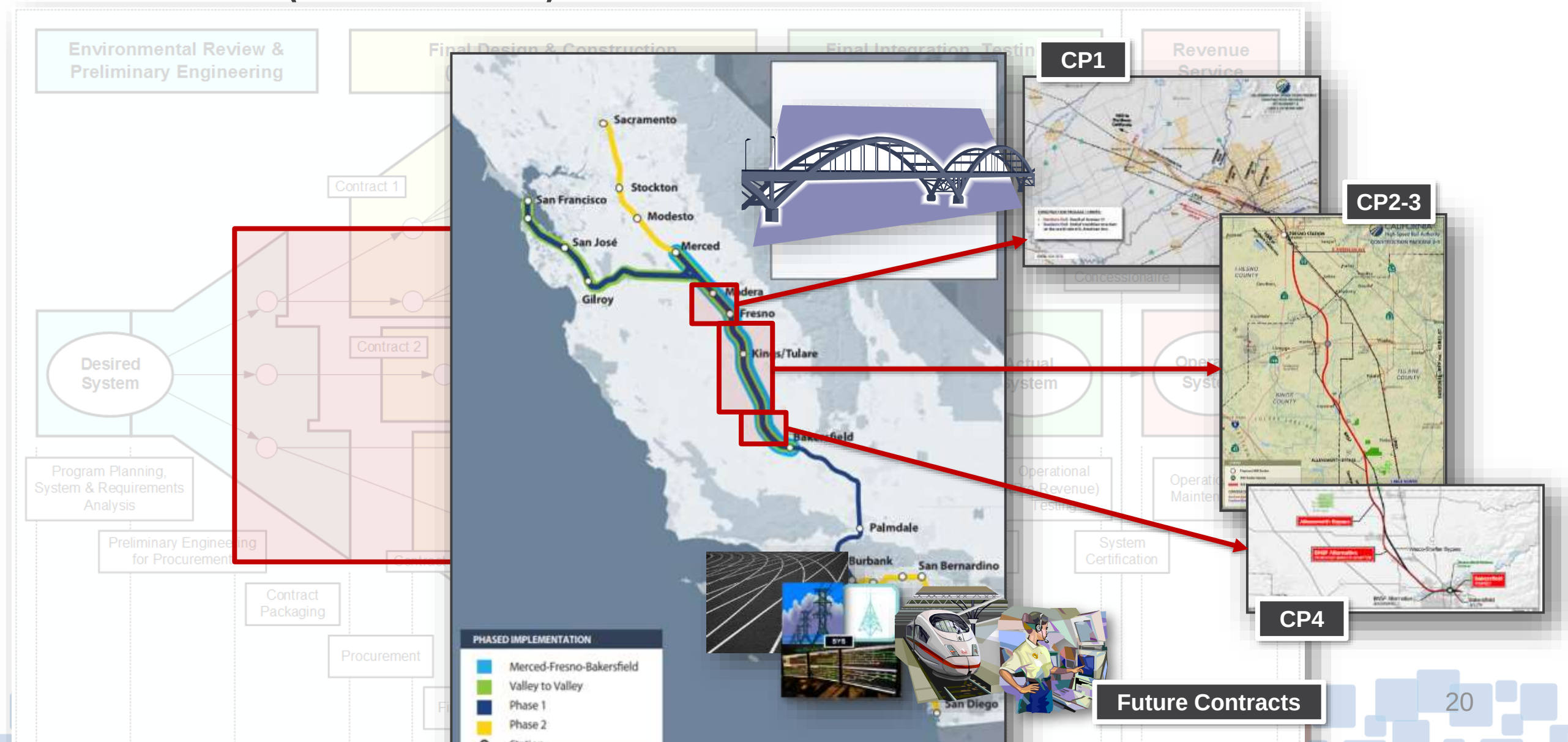
Systems Engineering Challenges Faced

Requirements Quantity



Systems Engineering Challenges Faced

Program of (Independent) Projects



Systems Engineering Challenges Faced

Number of Design/Construction Elements

River Crossing

Undercrossing

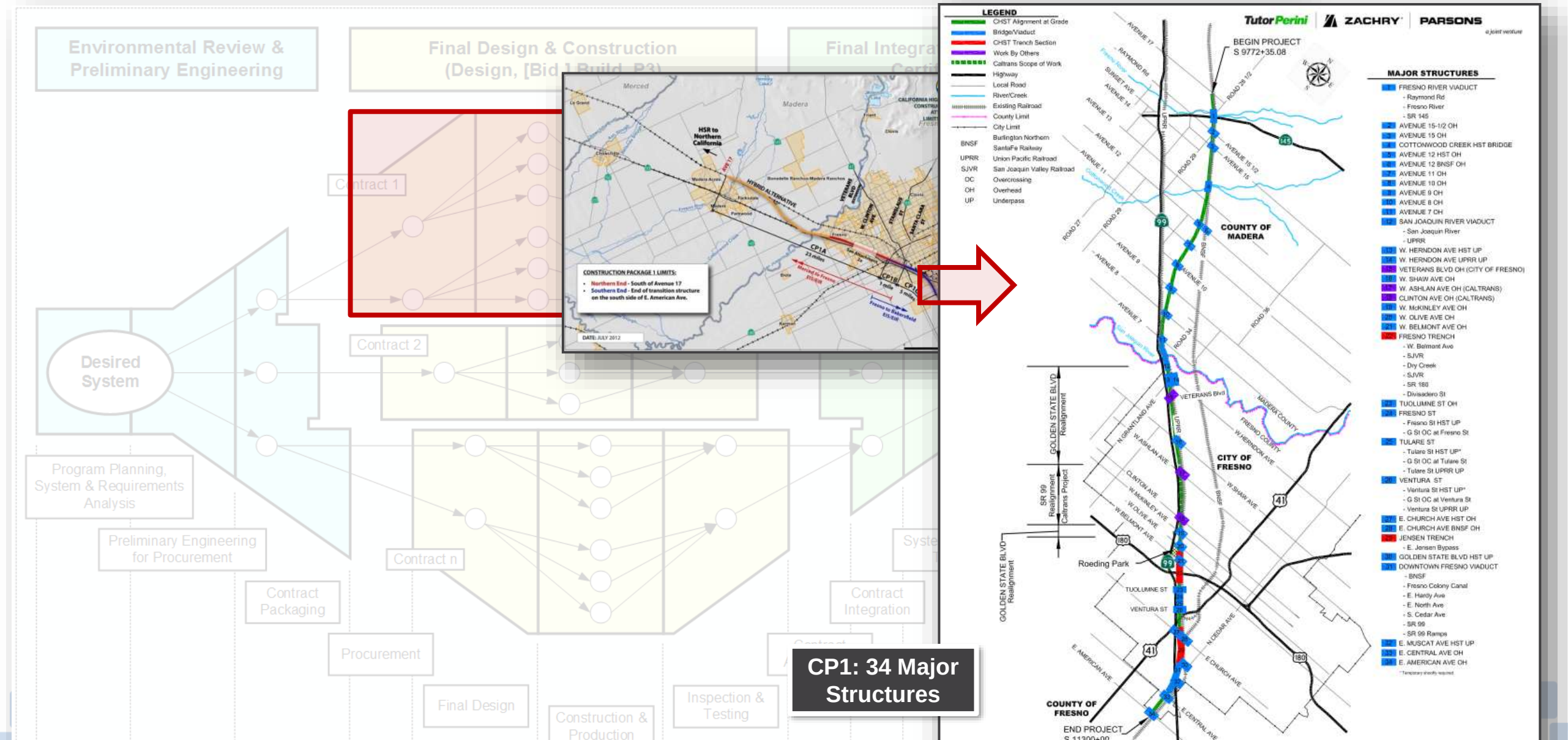
Trench

225+ Major Structures

Viaducts

SYSTEMS ENGINEERING CHALLENGES FACED

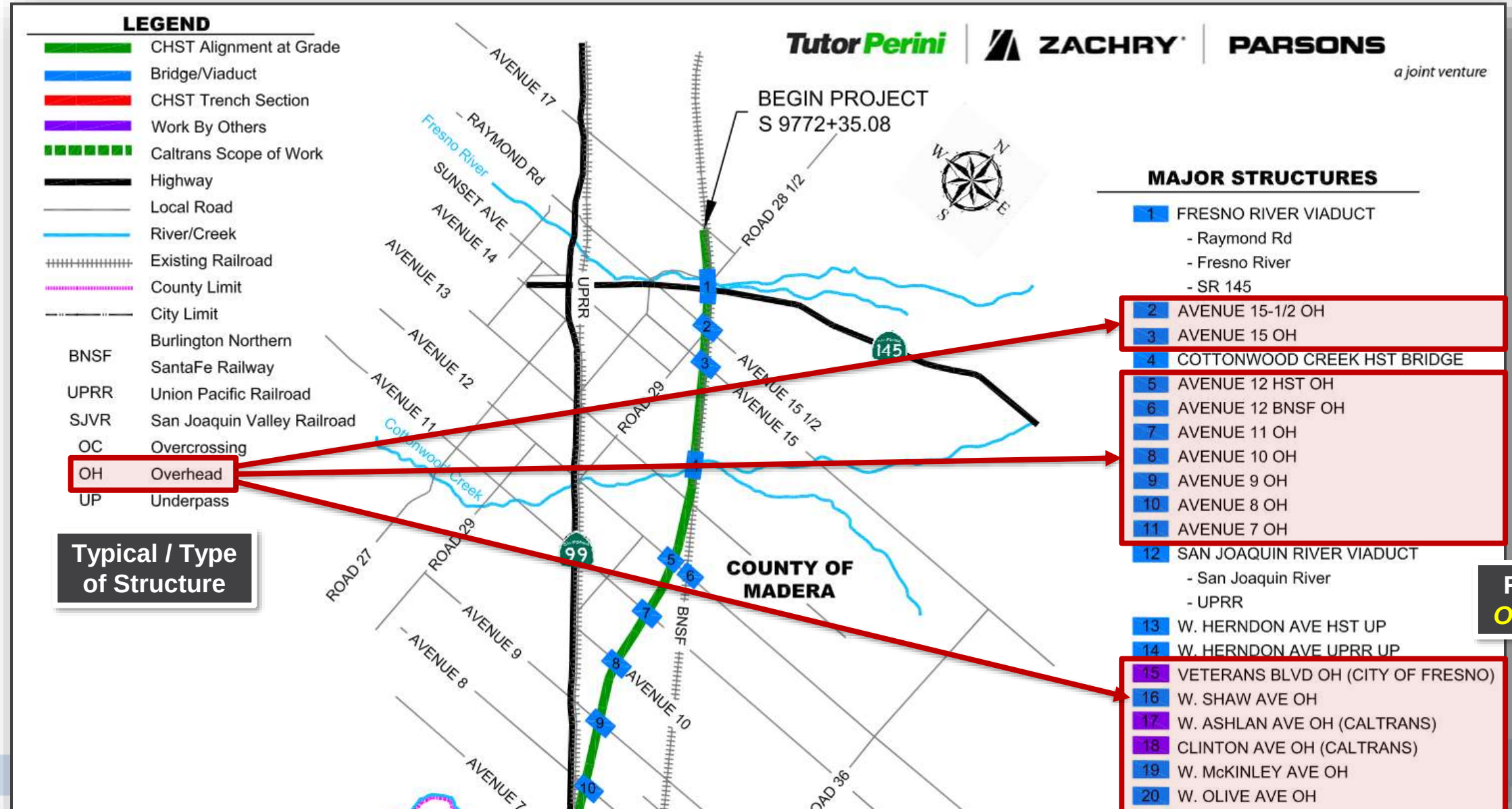
NUMBER OF DESIGN/CONSTRUCTION ELEMENTS



CP1: 34 Major Structures

SYSTEMS ENGINEERING CHALLENGES FACED

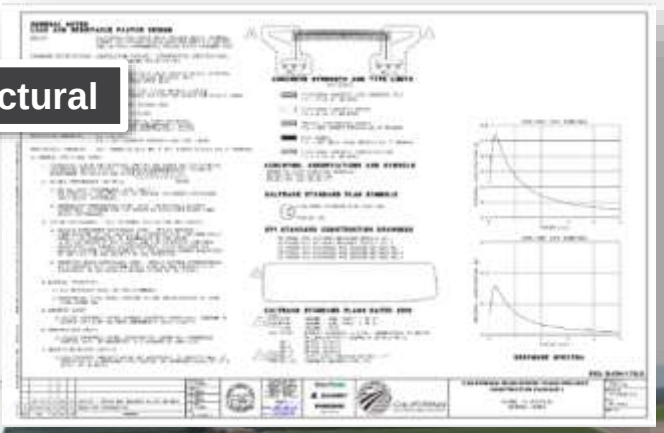
NUMBER OF DESIGN/CONSTRUCTION ELEMENTS (CONT'D)



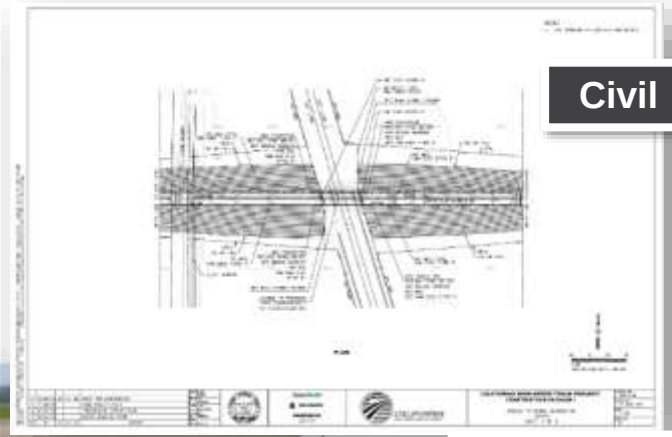
Systems Engineering Challenges Faced

Number of Design Submittals

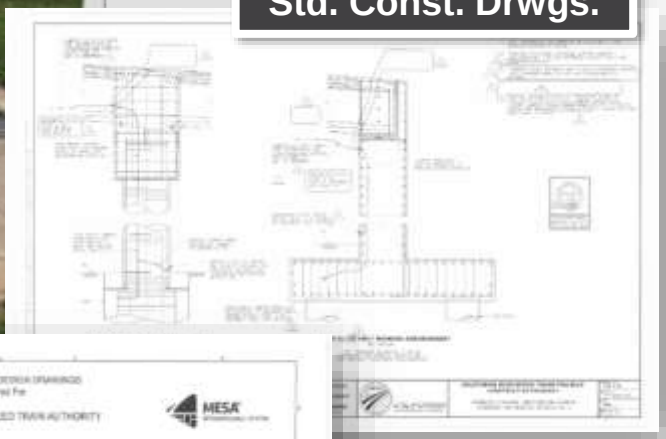
Structural



Civil



Std. Const. Drwgs.



Geotechnical

Retaining Walls

Systems Engineering Challenges Faced

Number of Design V&V Reports, Submittal Certifications

Structural

Civil

Certificates of Compliance

Std. Const. Drwgs.

Geotechnical

Retaining Walls

Systems Engineering Challenges Faced

Number of Submittal Records

Submittal Log

Avenue 10

Name		Title	SubmittalType
17699	...	FCN 227 Avenue 10 HST Box Culvert	INFO
17621	...	Avenue 10 OH Joint Seal	INFO
17536	...	Avenue 10 Pavement Remediation Plan	INFO
17469	...	Avenue 10 OH Construction SSCR	SONO
15564	...	Easem Avenu	
14656	...	Avenue 10 OH MSE Structure Pkg	APPROVAL
14435	...	Avenue 10 HST Box Culvert RFC	APPROVAL
11795	...	Avenue 10 HST Overhead SSCR	SONO
11774	...	60% Avenue 10 HST Box Culvert	SONO
11368	...	RFC Avenue 10 Overhead Design	APPROVAL
10926	...	Avenue 10 Grade Separation Design	INFO
10814	...	Avenue 10 Overhead GEDR	SONO
10699	...	90 Perc Dsgn Avenue 10 OH	SONO
10065	...	Avenue 8, Avenue 9, and Avenue 10	3RDPARTY

Safety & Security Certification Report

Fourth Revision

004		PCM_TPZP__03882_COF_Relocations	...	PCM_TPZP__03882_COF_Relocations.pdf
004	Signed Plan Set	2018May14_DCN081_Avenue_10_OH_Plans_Signed	...	2018May14_DCN081_Avenue_10_OH_Plans_S
004	CHSRA_trans_05027 Signed Plans DCN-081 Avenue 10 OH Design SW04.13.00-019-4	CHSRA_trans_05027_Signed_Plans_DCN_081_Avenue_10_OH_Design_SW04_13_00_019_4	...	CHSRA_trans_05027_Signed_Plans_DCN_081_
004	Authority's Response	SW04_13_00_019_4_RFC_Ave_10_OH_Design_Response	...	SW04_13_00_019_4_RFC_Ave_10_OH_Design_
004	DCN081 Avenue 10 Overhead Design	2017Oct31_DCN081_Ave_10_OH_DCN_Form	...	2017Oct31_DCN081_Ave_10_OH_DCN_Form.p
004	DCN081 Avenue 10 Overhead Design	2017Oct31_DCN081_Ave_10_OH_ISC_Statement_Resolution	...	2017Oct31_DCN081_Ave_10_OH_ISC_Stateme
004	DCN081 Avenue 10 Overhead Design	2017Oct31_DCN081_Ave_10_OH_ISC_Book	...	2017Oct31_DCN081_Ave_10_OH_ISC_Book.pd
004	DCN081 Avenue 10 Overhead Design	2017Oct31_DCN081_Ave_10_OH_GEDR	...	2017Oct31_DCN081_Ave_10_OH_GEDR.pdf
004	Submittal Cover Page	2018May16_SL_Cover_SW041300_019_4_DCN081_Ave_10_OH_Design	...	2018May16_SL_Cover_SW041300_019_4_DCN
004	DCN081 Avenue 10 Overhead Design	2018May14_DCN081_Ave_10_OH_CHSRA_Response	...	2018May14_DCN081_Ave_10_OH_CHSRA_Res
004	DCN081 Avenue 10 Overhead Design	2018May14_DCN081_Ave_10_OH_ICE_Cert	...	2018May14_DCN081_Ave_10_OH_ICE_Cert.pd
004	DCN081 Avenue 10 Overhead Design	2018May14_DCN081_Ave_10_OH_Plans	...	2018May14_DCN081_Ave_10_OH_Plans.pdf
004	DCN081 Avenue 10	2018May14_DCN081_Ave_10_OH_QA_Cert1386	...	2018May14_DCN081_Ave_10_OH_QA_Cert13

Design Change Notice (DCN)

Plans (Design Drawings)

000	RFC_AVenue_10_Overhead_Design	2015Dec03_Ave_10_OH_RFC_VV_Cert_Compliance	VV
000	RFC_AVenue_10_Overhead_Design	2015Dec03_Ave_10_OH_StcrtRpt_ICE_Assessment	Rpt

Verification & Validation, Submittal Certification

61 - 81

81 Files

Systems Engineering Challenges Faced

Allocated Requirements & Objective Evidence

Submittal Log

Avenue 10

Name		Title	SubmittalType
17699	...	FCN 227 Avenue 10 HST Box Culvert	INFO
17621	...	Avenue 10 OH Joint Seal	INFO
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10065	...	Avenue 8, Avenue 9, and Avenue 10	3RDPARTY

000	RFC_AVenue_10_Overhead_Design	2015Dec03_Ave_10_OH_RFC_VV_Cert_Compliance	
000	RFC_AVenue_10_Overhead_Design	2015Dec03_Ave_10_OH_StrtRpt_ICE_Assessment	

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Verification & Validation, Submittal Certification

California High-Speed Train Project
Construction Package 1

ID	Doc. ID	DOORS TCR #	Document Section	Technical Contract Requirement
86.	Design Criteria	CDPt22SR569	22.5 Ove	
87.	Design Criteria	CDPt03SR1963	3.3.1 Vertical Clearances	Minimum vertical clearances should b laterally from the centerline of the m
88.	Design Criteria	CDPt03SR24	3.3.1 Vertical Clearances	Minimum vertical clearances shall be of rail (TOR).
89.	Design Criteria	CDPt03SR46	3.3.2 Horizontal Clearances	Minimum horizontal clearances shall centerline (TCL) of the closest HST tra cleared.
90.	Scope of Work	SOW609	4.2.2 Review of Environmental Documents	Compliance with all Final Environmen demonstrated through preparation of reports, to be submitted with each de
91.	Design Criteria	CDPt06SR55	6.3.2 Protection Against Intrusion of Highway Vehicles over the HST Operating Infrastructure	The overhead structure shall be desig railing with sufficient strength to with
92.	Design Criteria	CDPt06SR56	6.3.2 Protection Against Intrusion of Highway Vehicles over the HST Operating	The vehicular railing shall extend to th feet beyond the end of the overhead taper to redirect vehicles that may tra embankment and into the Authority's
			Operating	onto the HST operating infrastructure

Contractor V&V Report
(Including Requirements Verification Traceability Matrix [RVTM])

Allocated Requirements
(Technical Contract Requirements [TCR])

California High-Speed Train
Design-Build Project

Construction Package 1

Avenue 10 Overhead RFC Design Submittal Verification and Validation Report

August 2015

Agreement No. HSR 13-06

Prepared by:

Tutor Perini | Zachry | Parsons

Avenue 10 OH RFC Design Submittal
Verification & Validation Report

In Compliance with Contract Documents	Reference
Yes	Overhead Standard Construction Drawings ST-K5020-STD, ST-K5021-STD, ST-5022-STD
Yes	ST-K1100-A10, Calcs. Section 2.3
Yes	ST-K1100-A10, Calcs. Section 2.3
Yes	ST-K1100-A10
Yes	Environmental Certification
Yes	ST-K1100-A10, ST-K3350-A10, Calcs. Section 3.2.2
Yes	ST-K1100-A10

Objective Evidence
(Reference and RM Tool Traces)

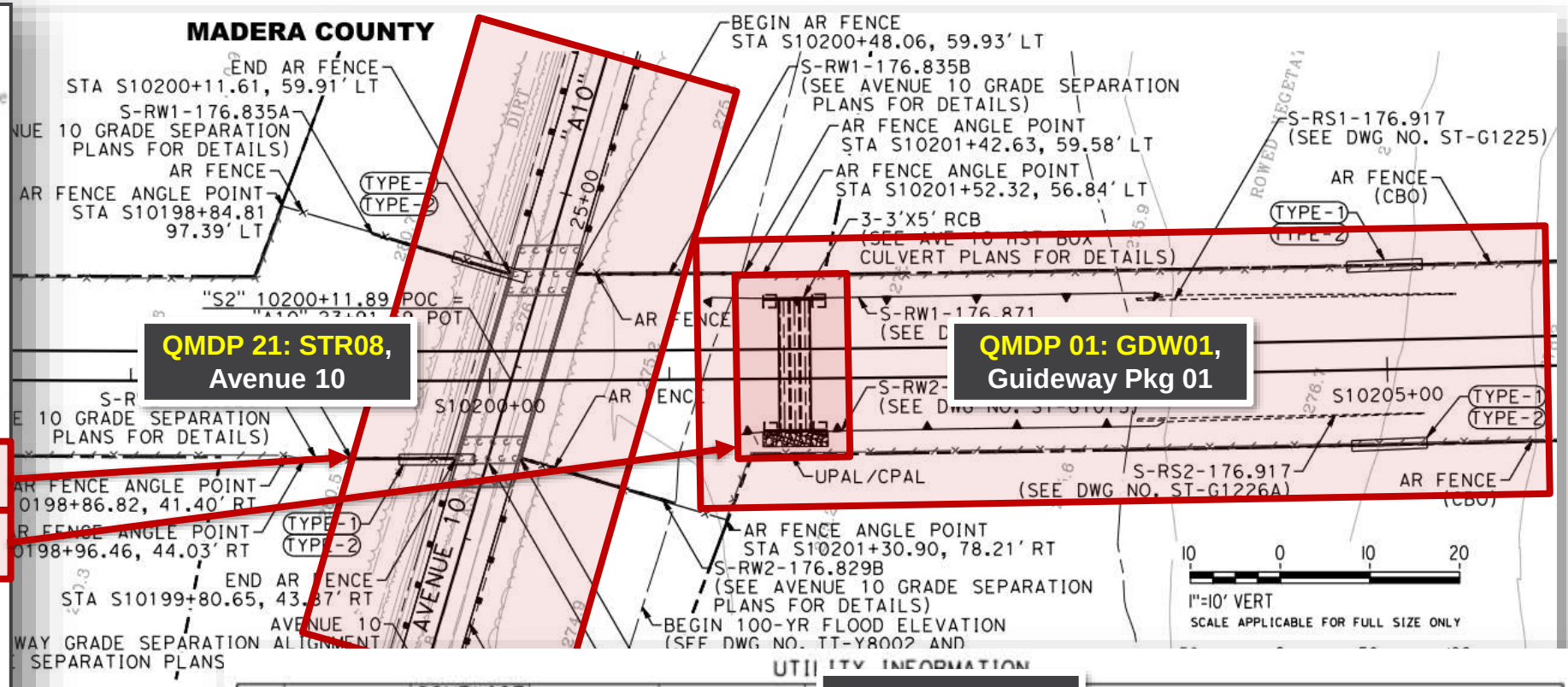
Systems Engineering Challenges Faced

Construction Certification: Quality Milestone (Data Pack, QMDP)

Submittal Log

Avenue 10

Name		Title	SubmittalType
17699	...	FCN 227 Avenue 10 HST Box Culvert	INFO
17621	...	Avenue 10 OH Joint Seal	INFO
17536	...	Avenue 10 Pavement Remediation Plan	INFO
17469	...	Avenue 10 OH Construction SSCR	SONO
15564	...	Easement T1-091 (AT&T) – Avenue 10	APPROVAL
14656	...	Avenue 10 OH MSE Structure Pkg	APPROVAL
14435	...	Avenue 10 HST Box Culvert RFC	APPROVAL
11795	...	Avenue 10 HST Overhead SSCR	SONO
11774	...	60% Avenue 10 HST Box Culvert	SONO
11368	...	RFC Avenue 10 Overhead Design	APPROVAL
10926	...	Avenue 10 Grade Separation Design	INFO
10814	...	Avenue 10 Overhead GEDR	SONO
10699	...	90 Perc Dsgn Avenue 10 OH	SONO
10065	...	Avenue 8, Avenue 9, and Avenue 10	3RDPARTY



QMDP 54: 3RDP002, PG&E

QMDP 53: 3RDP001, AT&T

UTILITY INFORMATION

NO.	FACILITY	CONFLICT NO.	SIZE	OWNER		DESIGN PLAN SET
1	OH POWER	E1-92	12kV	PG&E		TBD
2	IRRIGATION	IRR2-03	30"	MID	RELOCATE	MADERA IRRIGATION DISTRICT RECONSTRUCTION AND RELOCATION OF IRRIGATION FACILITIES LATERAL 6.2-14.0 AND LATERAL 6.2-9.2-5.0 IN MADERA COUNTY
3	TELECOM	T1-91	UNKNOWN	AT&T		RFC - (PROP. AT&T DUCTBANK AVE. 13, 12, 10, 9, 8, AND 7
4	STORM DRAIN	SDA-030	2-36"	AUTHORITY		ACK CIVIL GRADING AND DRAINAGE PLAN (STA S10192+00 TO S10220+00)
5	STORM DRAIN	SDA-032	3-3'x5'	AUTHORITY	PROPOSED	ACK CIVIL GRADING AND DRAINAGE PLAN (STA S10192+00 TO S10220+00)
6	IRRIGATION	IRR2-004	18"	MID	RELOCATE	MADERA IRRIGATION DISTRICT RECONSTRUCTION AND RELOCATION OF IRRIGATION FACILITIES LATERAL 6.2-14.0 AND LATERAL 6.2-9.2-5.0 IN MADERA COUNTY
7	IRRIGATION	IRR	UNKNOWN	MID	PROPOSED	MADERA IRRIGATION DISTRICT RECONSTRUCTION AND RELOCATION OF IRRIGATION FACILITIES LATERAL 6.2-14.0 AND LATERAL 6.2-9.2-5.0 IN MADERA COUNTY

SoS Engineering Challenges Faced

Independently Managed (& Operated) Projects (Constituent Sys.)

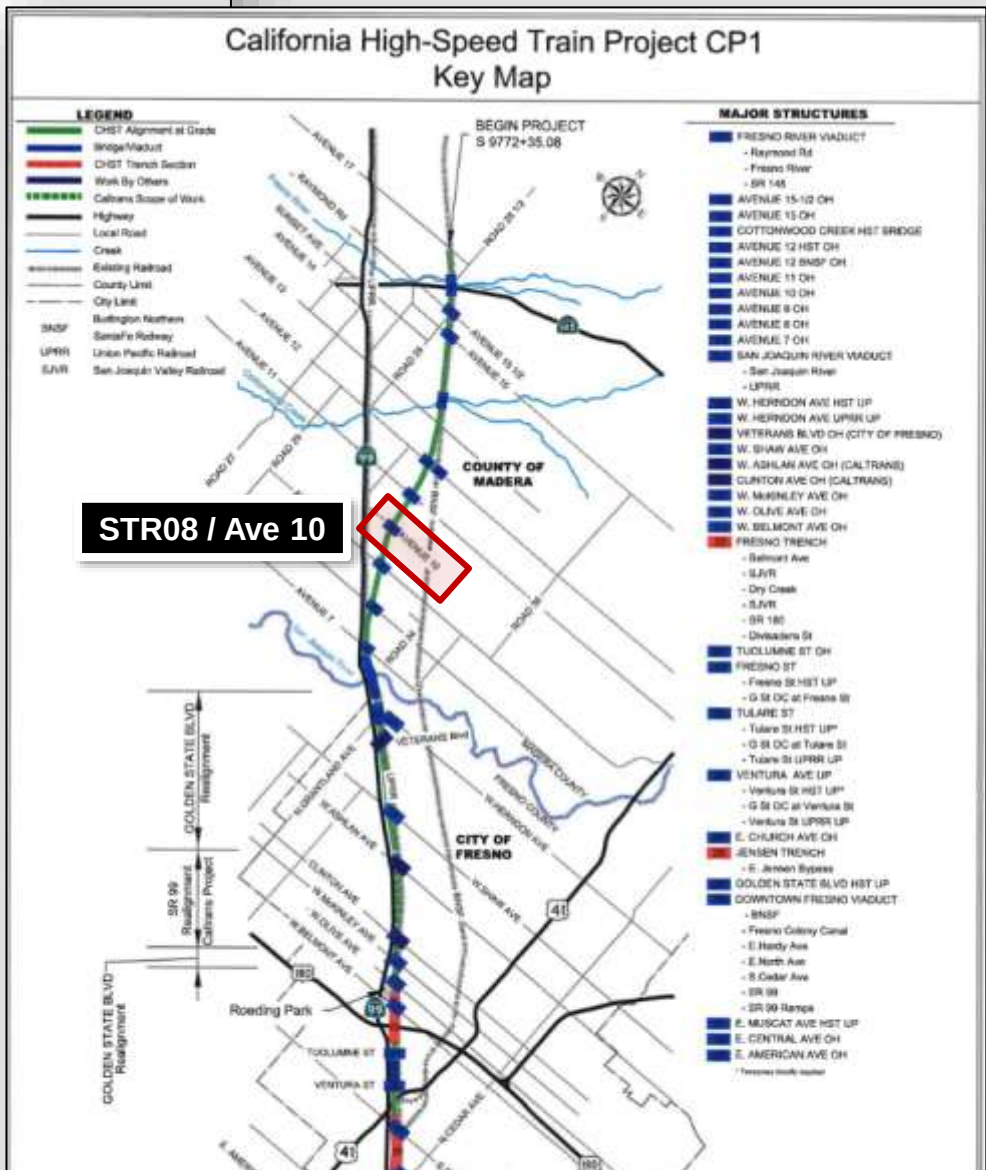
Milestones & the Field Engineers responsible for th

GDW01	MADERA COUNTY GUIDEWAY - Litto
GDW02	SJRV TO FRESNO TRENCH GUIDEWAY - Litto
GDW03	FRESNO TRENCH TO AMERICAN AVENUE GUIDEWAY - Litto
NE01	ROAD 26 - Katrina
NE02	SCHMIDT CREEK HST - Katrina
NE03	SCHMIDT CREEK CULVERT BOX - Katrina
NE04	WILDLIFE CROSSING MP167.4 - Katrina
NE05	ROAD 27 - Katrina
NE 06	AVE 17 - Katrina
STR01	FRESNO RIVER VIADUCT (FRV) - Gavin
STR02	AVENUE 15-1/2 OH - Katrina
STR03	AVENUE 15 OH - Katrina
STR04	COTTONWOOD CREEK BR - Katrina
STR05	AVENUE 12 HST OH - Katrina
STR06	AVENUE 12 BNSF OH - Katrina
STR07	AVENUE 11 OH - Katrina
STR08	AVENUE 10 OH - Katrina
STR09	AVENUE 9 OH - Katrina
STR10	AVENUE 8 OH - Katrina
STR11	AVENUE 7 OH - Katrina
STR12	SAN JOAQUIN RIVER VIADUCT (SJRV) - Doug
STR12A	W HERNDON AVE HST OP - Doug
STR12B	W HERNDON AVE UPRR OP - Doug
STR13	SHAW AVENUE OH – Sri
STR14	MCKINLEY AVENUE OH – Sri
STR15	OLIVE AVENUE OH – Sri
STR16	BELMONT AVENUE OH – Sri.
STR17	FRESNO TRENCH Tyler B
STR18	TUOLUMNE STREET OH – Matt K
STR19	FRESNO STREET UP - Gavin
STR20	TULARE STREET UP - Gavin
STR21	VENTURA AVENUE UP - Gavin
STR22	E CHURCH AVENUE HST - Gavin
STR22A	E CHURCH AVENUE BNSF OH - Gavin
STR23	JENSEN TRENCH Tyler B
STR 24B	E MUSCAT AVE HST - Gavin
STR25	CENTRAL AVENUE OH - Gavin
STR26	AMERICAN AVENUE OH - Gavin

STR08 / Ave 10

3RDP001	AT&T - Juan
3RDP002	PG&E - Bianca
3RDP003	CITY OF FRESNO - Bennie
3RDP004	COUNTY OF FRESNO - Bennie
3RDP005	COUNTY OF MADERA - Bennie
3RDP006	UPRR - Addison
3RDP007	BNSF - Addison
3RDP008	CALTRANS - Bennie
3RDP009	MADERA IRRIGATION DISTRICT - Greg
3RDP010	FRESNO IRRIGATION DISTRICT - Greg
3RDP011	FMFCD - Greg
3RDP012	KINDER MORGAN - Addison
3RDP013	LEVE III - Addison
3RDP014	COMCAST - Addison
3RDP015	SPRINT - Addison
3RDP016	TW TELECOM - Addison
3RDP017	TIME WARNER- Addison
3RDP018	QWEST - Addison
3RDP019	CVIN - Addison
3RDP020	SEBATIAN KERMAN TELECOM - Addison
3RDP021	MCI - Addison
3RDP022	SIERRA TELEPHONE - Addison

List of Quality Milestone Data Packs (QMDPs)



SoS Engineering Challenges Faced

Independently Managed (& Operated) Projects (Cont'd)

QUALITY MILESTONE ID				STRUCTURES	STATIONING	QUALITY MILESTONE ID			
						T-CIVIL TRACK			
R-CIVIL RDWY	S-RDWY STRUC	H-TRACK STRUC				NORTH/SOUTH		BNSF	
Management Segment 1 (STA 587+30 to 1595+00)									
				Start Segment 1	587+30	S1TN1	5000 ft		
S1R1	~~S1S1~~		~~1R-01~~	Lincoln (Cul-de-Sac)	630+30	ROW 1	0.95 mi		NEW
				End ROW 2	636+90	ROW 2			
				Start ROW 3	636+90	S1TN3	5278 ft		
S1R3	S1S3		1R-02	Adams OC	683+06	ROW 3	1.01 mi		
				End ROW 4	689+68	ROW 4			
				Start ROW 5	689+68	S1TN5			
				Start BNSF	707+00	ROW 5	5305 ft		
S1R5	S1S5		1R-03	South OC	735+89	ROW 6	1 mi		
				End ROW 6	742+73				
				Start ROW 7	742+73	S1TN7	5261 ft	S1TBN1	16200 ft
S1R7	S1S7		1R-04	Manning OC	788+82	ROW 7	0.996 mi		3.06 mi
	*S1S8		1R-05	Manning Change OC	788+83	ROW 8			
				End ROW 8	795+34				
				Start ROW 9	795+34	S1TN9	8482 ft		
				End BNSF	869+00	ROW 9	1.61 mi		
				End ROW 9	880+16				
				Start ROW 10	880+16	S1TN11	4209 ft		
S1R9	S1S9		1R-06	Floral OC	895+45	ROW 10	0.8 mi		
				End ROW 10	922+25				
				Start ROW 11	922+25	S1TN13			
				Start BNSF	932+00	ROW 11	6844 ft		
S1R11	S1S11		1R-07	Nebraska OC	953+20		1.296 mi		NEW
				End ROW11	990+69			S1TBN2	13000 ft
				Start ROW12	990+69	S1TN15			2.46 mi
S1R13	S1S13		1R-08	Mountain View OC	1004+61	ROW 12	8431 ft		
				End BNSF	1062+00	ROW 13	1.6 mi		
				End North Track	1075+00				
				Start South Track	1075+00				
		S1H1	1H-01	Conejo Ave AS	1114+48				
					1134+25	S1TS1	10185 ft		
S1R14		S1H3	1H-02	Peach Ave BR	1146+23	ROW 13	1.93 mi		
					1149+29				
				End ROW 13	1176+85				
				Start ROW 14	1176+85				
S1R15				Clarkson / Minnewawa	1175+00	S1TS3	5782 ft		
					1202+00	ROW 14	1.1 mi		
				REMOVED Clovis OC STA 1221+78					
				End ROW 14	1234+67				
				Start ROW 15	1234+67	S1TS5			
S1R17	S1S15		1R-10	Elkhorn OC	1247+36	ROW 15	8026 ft		
S1R19	S1S17		1R-11	Fowler OC	1276+61	ROW 16	1.52 mi		
				End ROW 16	1314+93				
				Start ROW 17	1314+93	S1TS7	8007 ft		

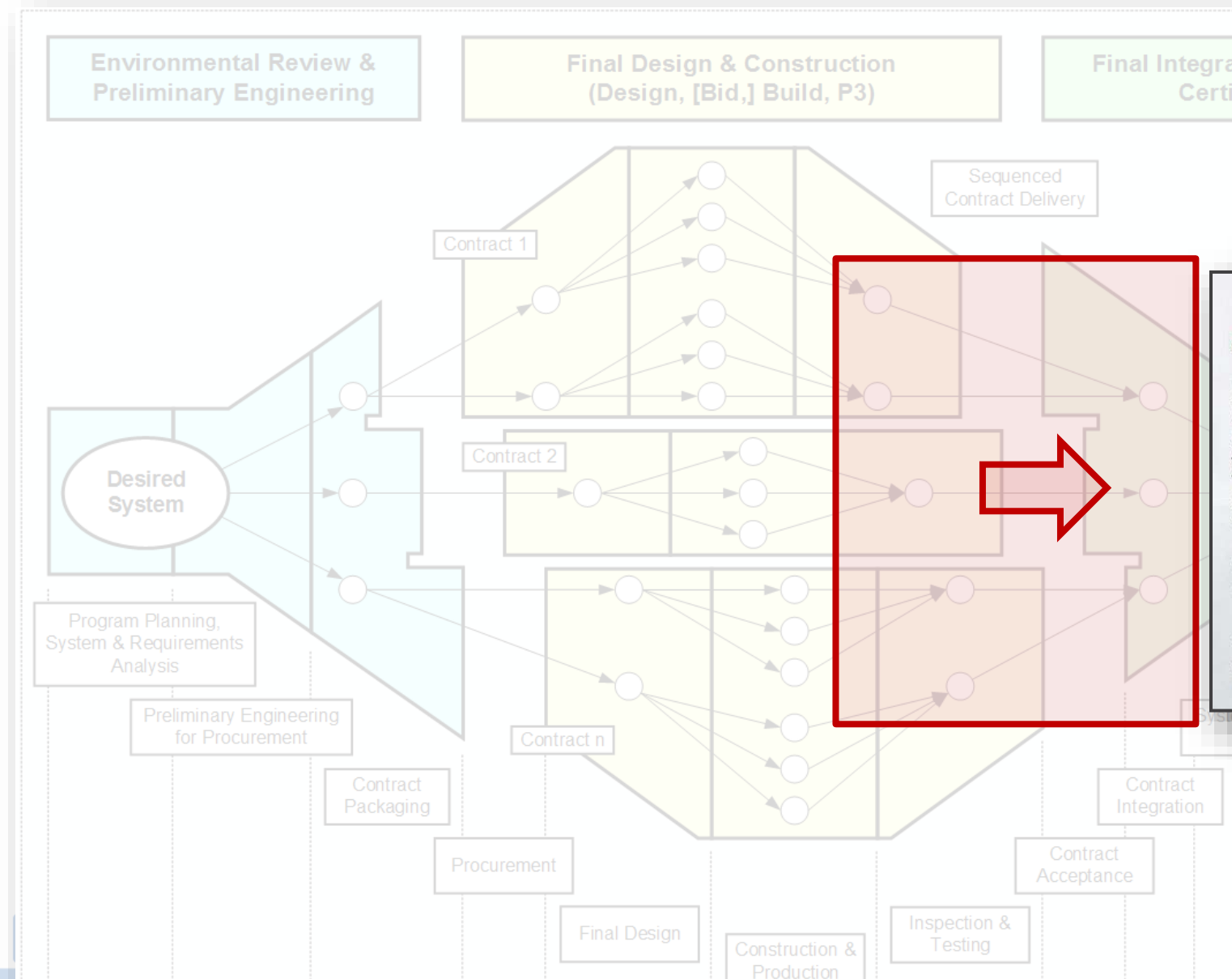
CP2-3

CP4

#	Activity ID	QMDP #	Activity Name	Stationing
1	MIL_1285	QMDP 01	EOP to County Line	14769+23 - 14822+00
2	MIL_1290	QMDP 02	County Line to S Scofield	14822+00 - 14877+00
3	MIL_1295	QMDP 03	S Scofield to Garces Abut1	14877+00 - 14931+21
4	MIL_1145	QMDP 04	Garces Hwy Underpass	14931+31 - 14932+23
5	MIL_1300	QMDP 05	Garces Abut. 2 to Woollomes Ave	14932+23 - 14989+50
6	MIL_1305	QMDP 06	Woollomes Ave to Pump Station	14989+50 - 15055+00
7	MIL_1310	QMDP 07	Pump Stat ion to S. Magnolia	15055+00 - 15096+50
8	MIL_1315	QMDP 08	S. Magnolia to Pond Rd. Abut. #1	15096+50 - 15119+73
9	MIL_1115	QMDP 09	Pond Rd Underpass	15119+72 - 15120+94
10	MIL_1320	QMDP 10	Pond Rd. Abut. 2 to Peterson Rd. Abut. 1	15120+94 - 15182+09
11	MIL_1155	QMDP 11	Peterson Rd Underpass	15182+09 - 15183+11
12	MIL_1325	QMDP 12	Peterson Rd. Abut. 1 to Elmo Hwy	15183+12 - 15242+00
13	MIL_1330	QMDP 13	Elmo Hwy to Sherwood Ave	15242+00 - 15294+50
14	MIL_1335	QMDP 14	Sherwood Ave to Poso Creek Abut. 1	15294+50 - 15329+88
15	MIL_1105	QMDP 15	Poso Creek Overpass	15329+89 - 15332+27
16	MIL_1340	QMDP 16	Poso Creek Abut. 1 to Taussig Ave.	15332+27 - 15375+50
17	MIL_1345	QMDP 17	Taussig Ave to Canal 9-22	15375+50 - 15426+88
18	MIL_1350	QMDP 18	Canal 9-22 to McCombs Ave.	15426+88 - 15505+00
19	MIL_1185	QMDP 19	McCombs Ave Overpass	15501+55 - 15501+95
20		QMDP 20	McCombs Ave.to SR-46 Abut. 1	15509+00 - 15560+89
21		QMDP 21	SR 46 Underpass	15560+89 - 15562+12
22	MIL_1360	QMDP 22	SR-46 Abut. 1 to Pedestrian Underpass	15563+00 - 15587+00
23	MIL_1085	QMDP 23	HST Pedestrian Underpass	15588+25 - 15590+25
24	MIL_1365	QMDP 24	Pedestrian Underpass to Poso Ave	15590+00 - 15614+00
25	MIL_1195	QMDP 25	Poso Ave Underpass	15613+83 - 15614+43
26	MIL_1370	QMDP 26	Poso Ave to Wasco Viaduct Abut. 1	15614+00 - 15660+00
27	MIL_1270	QMDP 27	Wasco Viaduct	15660+20 - 15679+73

SoS Engineering Challenges Faced

Certification Approach: Putting It All Back Together



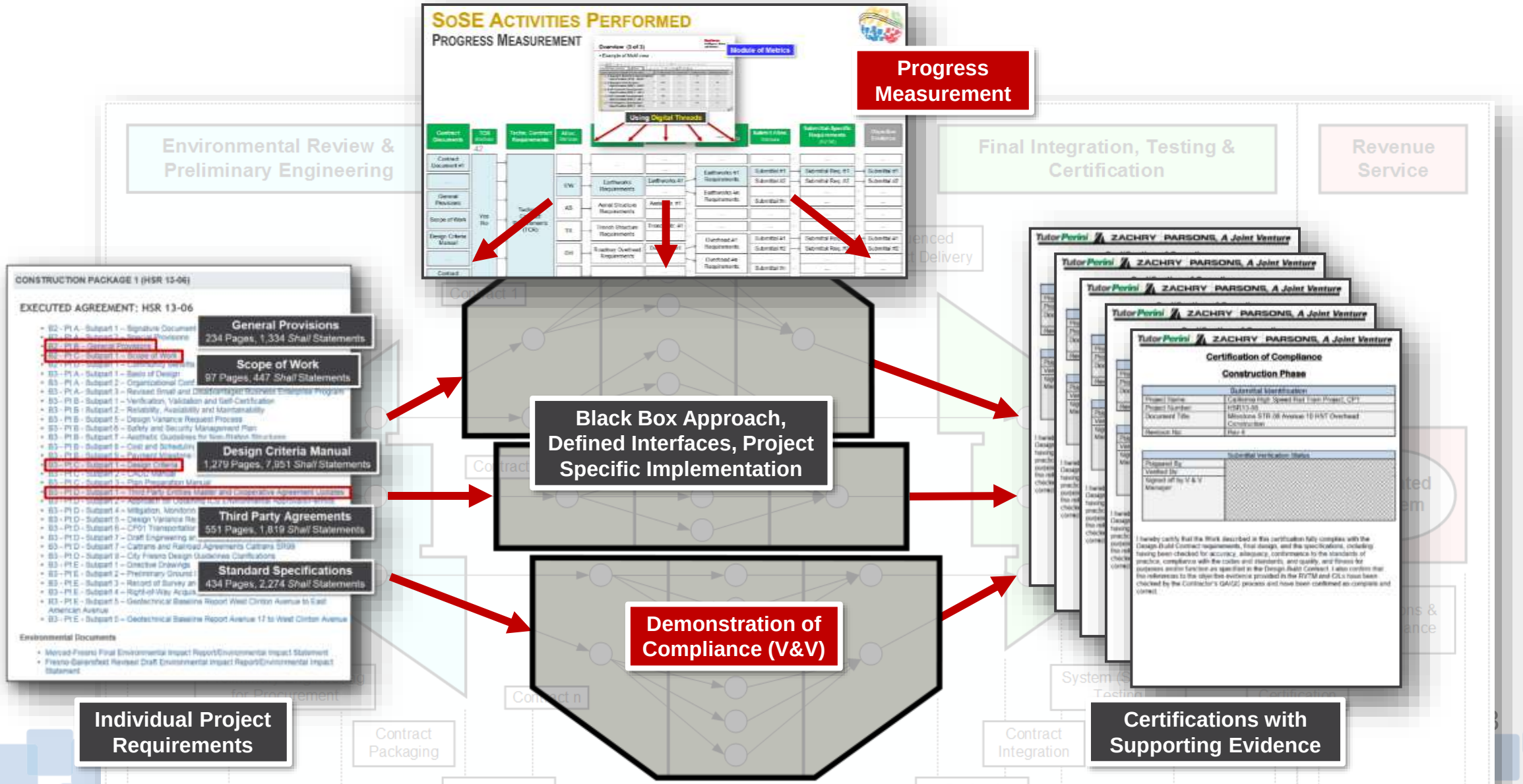
Source/Credit: https://garagesimeone.ch/portfolio-view/originalteile/

PROGRESS

- **Introduction**
  - Brief System of Systems (SoS) Overview
  - California High-Speed Rail System (CHSRS) Program
  - Use of Digital Threads in the CHSRS Program
- **SoSE Challenges Faced**
  - Systems Engineering Challenges
  - SoS Engineering Challenges
- **SoSE Activities Performed**
  - Certification Strategy
  - Step by Step Process Description
- **Summary, Achieved Outcomes & Conclusion**

SoSE Activities Performed

High-Level Verification, Validation & Certification Strategy



SoSE Activities Performed

Verification & Validation Approach

Contract Documents	TCR Attribute	Techn. Contract Requirements	Alloc. Attribute	General / Typical Requirements	Site Alloc. Attribute	Site-Specific Requirements	Submit Alloc. Attribute	Submittal-Specific Requirements (RVTM)	Objective Evidence
Contract Document #1	Yes / No	Technical Contract Requirements (TCR)	RM Tool Attributes: EW	...	...	...	...	...	...
...		RM Tool Modules			...				
General Provisions			AS	Earthworks Requirements	Earthworks #1	Earthworks #1 Requirements	Submittal #1	Submittal Req. #1	Submittal #1
Scope of Work				RM Tool Links (Digital Threads)	...	Earthworks #n Requirements	Submittal #2	Submittal Req. #2	Submittal #2
Design Criteria Manual			TR		Aerial Str. #1		...	...	...
...					...		Submittal #n	...	...
Contract			OH	Trench Structure Requirements	Trench Str. #1	...	...	...	...
					...	...	...	...	...
				Roadway Overhead Requirements	Overhead #1	Overhead #1 Requirements	Submittal #1	Submittal Req. #1	Submittal #1
					...	Overhead #n Requirements	Submittal #2	Submittal Req. #2	Submittal #2
					...		...	...	...
					...		Submittal #n	...	...

SoSE Activities Performed

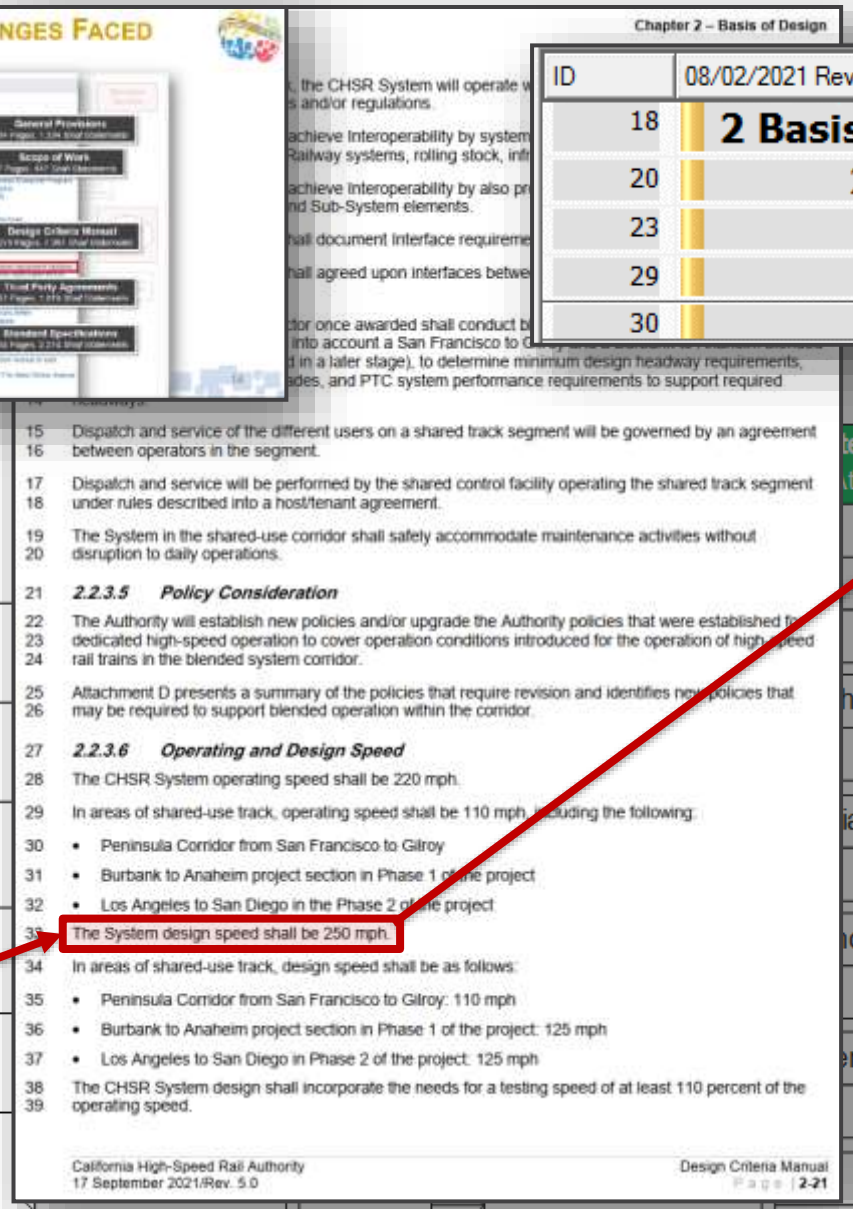
Verification & Validation Approach: 6 Key Steps

Contract Documents	TCR Attribute	Techn. Contract Requirements	Alloc. Attribute	General / Typical Requirements	Site Alloc. Attribute	Site-Specific Requirements	Submit Alloc. Attribute	Submittal-Specific Requirements (RVTM)	Objective Evidence
Contract			...		...	...	...	...	...
Step 1 Contract Requirements		**Step 2** Technical Contract Req.		**Step 3** Type Requirements		**Step 4** Site-Specific Requirements		**Step 5** Submittal-Specific Requirements	**Step 6** Objective Evidence
General Provisions							Submittal #1		
Scope of Work	Yes / No	Technical Contract Requirements (TCR)	EW		Earthworks #1		Submittal #2		
Design Criteria Manual					...	Earthworks #n Requirements	...		
...			AS	Aerial Structure Requirements	Aerial Str. #1		Submittal #n		
Contract					...	...	...	...	...
			TR	Trench Structure Requirements	Trench Str		...	...	...
					...		...	...	...
			OH	Roadway Overhead Requirements	Overhead #1	Overhead #1 Requirements	Submittal #1	Submittal Req. #1	Submittal #1
					...		Submittal #2	Submittal Req. #2	Submittal #2
						Overhead #n Requirements	...	...	...
					...		Submittal #n	...	...
					...	...	...	...	...

Digital Threads

SoSE Activities Performed

Performance Req. Example: Step 1 – Contract Requirements



ID	08/02/2021 Rev. 4.5 - BOD	_TCR
18	2 Basis of Design	Heading
20	2.2 Design Criteria Elements	Heading
23	2.2.3 Train Operation	Heading
29	2.2.3.6 Operating and Design Speed	Heading
30	The System design speed shall be 250 mph.	TCR

Contract Documents	TCR Attribute	Alloc. Attribute	Site-Specific Requirements	Submit Alloc. Attribute	Submittal-Specific Requirements (RVTM)	Objective Evidence
Contract Document #1	Yes No	...	...	...	...	...
...		...				
General Provisions		hworks #1	Earthworks #1 Requirements	Submittal #1	Submittal Req. #1	Submittal #1
Scope of Work				Submittal #2	Submittal Req. #2	Submittal #2
Design Criteria Manual		...	Earthworks #n Requirements	...	...	...
...		ial Str. #1		Submittal #n	...	...
Contract		...	...	...	...	...
		nch Str. #1	...	...	...	...
		...				
		erhead #1	Overhead #1 Requirements	Submittal #1	Submittal Req. #1	Submittal #1
				Submittal #2	Submittal Req. #2	Submittal #2
		...	Overhead #n Requirements	...	...	...
		...		Submittal #n	...	...

SoSE Activities Performed

Performance Req. Example: Step 2 – Technical Contract Reqs.

Contract Documents | TCR Attribute | Techn. Contract Requirements

- Contract Document #1
- ...
- General Provisions
- Scope of Work
- Design Criteria Manual
- ...
- Contract

Yes / No

Technical Contract Requirements (TCR)

ID	Technical Contract Requirements (TCR)	ABL
TCR.1	**1 General Provisions**	---
TCR.45	**1.44 Sustainability**	---
TCR.47	**1.44.2 Requirements**	---
TCR.48	k. The Contractor shall provide Environmental Product Declarations from its suppliers and manufacturers for concrete mix designs used in elements of the Project, including pre-cast and cast-in-place concrete, and all steel. The Contractor shall enter and upload Environmental Product Declarations in EMMA for concrete and steel.	PW
TCR.49	**2 Scope of Work**	---
TCR.53	**2.4 PROJECT SCOPE OF WORK**	---
TCR.64	**2.4.9 Design Reports**	---
TCR.66	**2.4.9.2 Hydrology and Hydraulic Reports**	---
TCR.67	Contractor shall prepare Hydrology and Hydraulics Reports to support the drainage design of the full build-out of the CHSR trackway, as well as the temporary drainage system for the interim condition.	PW
TCR.68	Contractor shall contact and coordinate with State (NOAA Atlas 14, Volume 6, Version 2) and local (City of Bakersfield - Subdivision & Engineering Design Manaul, Division 7) jurisdictions to obtain necessary information for preparation of its reports.	PW
TCR.69	**3 Design Criteria**	---
TCR.71	**3.2 Basis of Design**	
TCR.73	**3.2.2 Design Criteria Elements**	
TCR.76	**3.2.2.3 Train Operation**	
TCR.82	**3.2.2.3.6 Operating and Desig...**	
TCR.83	The System design speed shall be 250 mph.	PW EW AS
TCR.87	**3.6 Reliability, Availability, and Maintainability**	---
TCR.256	**3.6.2 Design Criteria Elements**	---

040 Design Analyses/050 ABL/010 SYS/010 PW-TCR
040 Design Analyses/050 ABL/020 SUB-SYS/020 EW-TCR
040 Design Analyses/050 ABL/020 SUB-SYS/030 AS-TCR

Digital Threads

SoSE Activities Performed

Performance Req. Example: Step 3 – Typical (EW) Requirements

Techn. Contract Requirements	Alloc. Attribute	General / Typical Requirements
Technical Contract Requirements (TCR)	...	...
	EW	Earthworks Requirements
	AS	Aerial Structure Requirements
	TR	Trench Structure Requirements
	OH	Roadway Overhead Requirements
	...	...

HSR Earthworks (Type) Applicable (Subsets) TCRs

	Sites
3 Design Criteria	
3.2 Basis of Design	
3.2.2 Design Criteria Elements	
3.2.2.3 Train Operation	
3.2.2.3.6 Operating and Design Speed	
The System design speed shall be 250 mph.	EW-EMB-SITE01 EW-CUT-SITE02
3.29 Geotechnical	
3.29.2 Design Criteria Elements	
3.29.2.6 Earthworks	
3.29.2.6.1 Earthwork Materials	
3.29.2.6.1.3 HSR Prepared Subgrade	
The required minimum thickness of the Prepared Subgrade is as follows: • Ballasted track on embankment or in a cut: 14 inches. • Slab track on embankment, where embankment height is equal to or greater than 6.5 feet (as measured from the top of the prepared subgrade at the side edge of the embankment to the existing ground surface): 6.5 feet.	EW-EMB-SITE01 EW-CUT-SITE02
5 Supplemental Contract Requirements	
5.2 Engineering and Construction UPRR Agreement	
5.2.3 Design and Construction	
(d) Except as may be permitted in UPRR-approved Final Plans, at any location where the centerline of CHSRA tracks will be designed to be 102 feet or closer to UPRR's property, CHSRA must design, construct, and maintain intrusion barriers between the CHSRA tracks and UPRR's property. UPRR acknowledges that CHSRA will seek many such exceptions when it reasonably believes that approval of an exception would not have an adverse impact on safe or efficient operations.	EW-EMB-SITE01

Allocations to Individual Sites

SoSE Activities Performed

Performance Req. Example: Step 4 – Site-Specific Requirements

General / Typical Requirements	Site Alloc. Attribute	Site-Spec Requirem
...	...	...
	...	
Earthworks Requirements	Earthworks #1	Earthwork Requirem
	...	Earthwork Requirem
Aerial Structure Requirements	Aerial Str. #1	
	...	...
Trench Structure Requirements	Trench Str. #1	...
	...	
Roadway Overhead Requirements	Overhead #1	Overhead Requirem
	...	Overhead Requirem
	...	

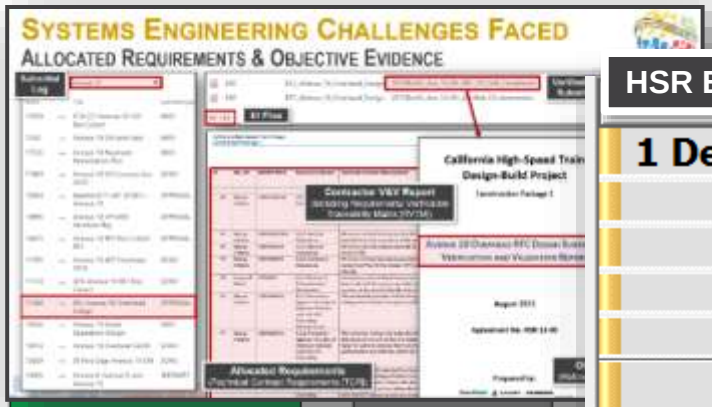
HSR Earthworks #1 (Site-Specific Applicable (Subsets) TCRs

	Submittals
1 Design Criteria	---
1.2 Basis of Design	
1.2.2 Design Criteria Elements	
1.2.2.3 Train Operation	
1.2.2.3.6 Operating and Design Speed	
The System design speed shall be 250 mph.	EW-DES-60% EW-DES-90% EW-DES-RFC EW-DES-DCN
1.29 Geotechnical	
1.29.2 Design Criteria Elements	
1.29.2.6 Earthworks	
1.29.2.6.1 Earthwork Materials	
1.29.2.6.1.3 HSR Prepared Subgrade	
The required minimum thickness of the Prepared Subgrade is as follows: • Ballasted track on embankment or in a cut: 14 inches. • Slab track on embankment, where embankment height is equal to or greater than 6.5 feet (as measured from the top of the prepared subgrade at the side edge of the embankment to the existing ground surface): 6.5 feet.	EW-DES-60% EW-DES-90% EW-DES-RFC EW-DES-DCN
3 Supplemental Contract Requirements	
3.2 Engineering and Construction UPRR Agreement	
3.2.3 Design and Construction	
(d) Except as may be permitted in UPRR-approved Final Plans, at any location where the centerline of CHSRA tracks will be designed to be 102 feet or closer to UPRR's property, CHSRA must design, construct, and maintain intrusion barriers between the CHSRA tracks and UPRR's property. UPRR acknowledges that CHSRA will seek many such exceptions when it reasonably believes that approval of an exception would not have an adverse impact on safe or efficient operations.	EW-DES-60% EW-DES-90% EW-DES-RFC EW-DES-DCN

Allocations to Submittals

SoSE Activities Performed

Performance Req. Example: Step 5 – Submittal Specific Reqs.



Submittal-Specific Requirements (RVTM)

Objective Evidence

...	...
Submittal Req. #1	Submittal #1
Submittal Req. #2	Submittal #2
...	...
...	...
...	...
...	...
Submittal Req. #1	Submittal #1
Submittal Req. #2	Submittal #2
...	...
...	...

HSR Earthworks Submittal (Requirements Verification Traceability Matrix)

		Subm-Name	Dwg-ID	Drawing Name
1 Design Criteria				
1.2 Basis of Design				
1.2.2 Design Criteria Elements				
1.2.2.3 Train Operation	Submittal		Reference to Objective Evidence	
1.2.2.3.6 Operating and Design Speed				
The System design speed shall be 250 mph.	14060	GDW01	TT-D0001	TRACK GUIDEWAY - HORIZONTAL ALIG
			TT-E6001	TRACK CHART - SHEET 1 OF 13
			TT-E6002	TRACK CHART - SHEET 2 OF 13
			TT-E6003	TRACK CHART - SHEET 3 OF 13
			TT-E6004	TRACK CHART - SHEET 4 OF 13
1.29 Geotechnical				
1.29.2 Design Criteria Elements				
1.29.2.6 Earthworks				
1.29.2.6.1 Earthwork Materials				
1.29.2.6.1.3 HSR Prepared Subgrade				
The required minimum thickness of the Prepared Subgrade is as follows: • Ballasted track on embankment or in a cut: 14 inches. • Slab track on embankment, where embankment height is equal to or greater than 6.5 feet (as measured from the top of the prepared subgrade at the side edge of the embankment to the existing ground surface): 6.5 feet.	14060	GDW01	TT-D3001	TYPICAL TRACK SECTION - SHEET 1 O
			TT-D3002	TYPICAL TRACK SECTION - SHEET 2 O
			TT-D3003	TYPICAL TRACK SECTION - SHEET 3 O
			TT-D3004	TYPICAL TRACK SECTION - SHEET 4 O
			TT-D3005	TYPICAL TRACK SECTION - SHEET 5 O
			TT-D3006	TYPICAL TRACK SECTION - SHEET 6 O
			TT-D3007	TYPICAL TRACK SECTION - SHEET 7 O
			TT-D3008	TYPICAL TRACK SECTION - SHEET 8 O
			TT-D3009	TYPICAL TRACK SECTION - SHEET 9 O
			TT-D3010	TYPICAL TRACK SECTION - SHEET 10 O
			TT-D3011	TYPICAL TRACK SECTION - SHEET 11 O
			TT-D3012	TYPICAL TRACK SECTION - SHEET 12 O
			TT-D3013	TYPICAL TRACK SECTION - SHEET 13 O
			TT-D3014	TYPICAL TRACK SECTION - SHEET 14 O

SoSE Activities Performed

Performance Req. Example: Step 6 – Submittal Log & Repository

	Subm-ID	Subm-Name	Drwg-ID	Drawing Name	Drwg-Rev
1 Design Criteria					
1.2 Basis of Design					
1.2.2 Design Criteria Elements					
1.2.2.3 Train Operation					
1.2.2.3.6 Operating and Design Speed					
The System design speed shall be 250 mph.	14060	GDW01	TT-D0001	TRACK GUIDEWAY - HORIZONTAL ALIGNMENT DATA TABLE	0
			TT-E6001	TRACK CHART - SHEET 1 OF 13	0
			TT-E6002	TRACK CHART - SHEET 2 OF 13	0
			TT-E6003	TRACK CHART - SHEET 3 OF 13	0
			TT-E6004	TRACK CHART - SHEET 4 OF 13	0
1.29 Geotechnical					
1.29.2 Design Criteria Elements					
1.29.2.6 Earthworks					

Submittal

Reference to Objective Evidence

Submittal Log	Subm-ID	Sub Name (Short)	Sub Name (Full)
1 Submittal Log			
1.3 HSR Earthworks			
1.3.1 EW-EMB-SITE01	---	---	---
RFC	14060	GDW01	Guideway Package 1, RFC
1.4 HSR Aerial Structure			
1.4.1 AS-VD-SITE01	---	---	---
RFC	11893	FRV, RFC	Fresno River Viaduct, RFC
Drawings			
V&V Submittal			
Certification of Compliance			

Drawing #	Drawing Name
GE-D0001	COVER SHEET
...	...
TT-D0001	TRACK GUIDEWAY - HORIZONTAL ALIGNMENT DATA TABLE
TT-E6001	TRACK CHART - SHEET 1 OF 13
TT-E6002	TRACK CHART - SHEET 2 OF 13
TT-E6003	TRACK CHART - SHEET 3 OF 13
TT-E6004	TRACK CHART - SHEET 4 OF 13
TT-D3001	TYPICAL TRACK SECTION - SHEET 1 OF 14
TT-D3002	TYPICAL TRACK SECTION - SHEET 2 OF 14
TT-D3003	TYPICAL TRACK SECTION - SHEET 3 OF 14
TT-D3004	TYPICAL TRACK SECTION - SHEET 4 OF 14
TT-D3005	TYPICAL TRACK SECTION - SHEET 5 OF 14
TT-D3006	TYPICAL TRACK SECTION - SHEET 6 OF 14
TT-D3007	TYPICAL TRACK SECTION - SHEET 7 OF 14
TT-D3008	TYPICAL TRACK SECTION - SHEET 8 OF 14
TT-D3009	TYPICAL TRACK SECTION - SHEET 9 OF 14
	TYPICAL TRACK SECTION - SHEET 10 OF 14
	TYPICAL TRACK SECTION - SHEET 11 OF 14
	TYPICAL TRACK SECTION - SHEET 12 OF 14
TT-D3013	TYPICAL TRACK SECTION - SHEET 13 OF 14

CP2-3, CP4: Submittal Log

New CPx: Submittal Repository (Example: Drawing List)

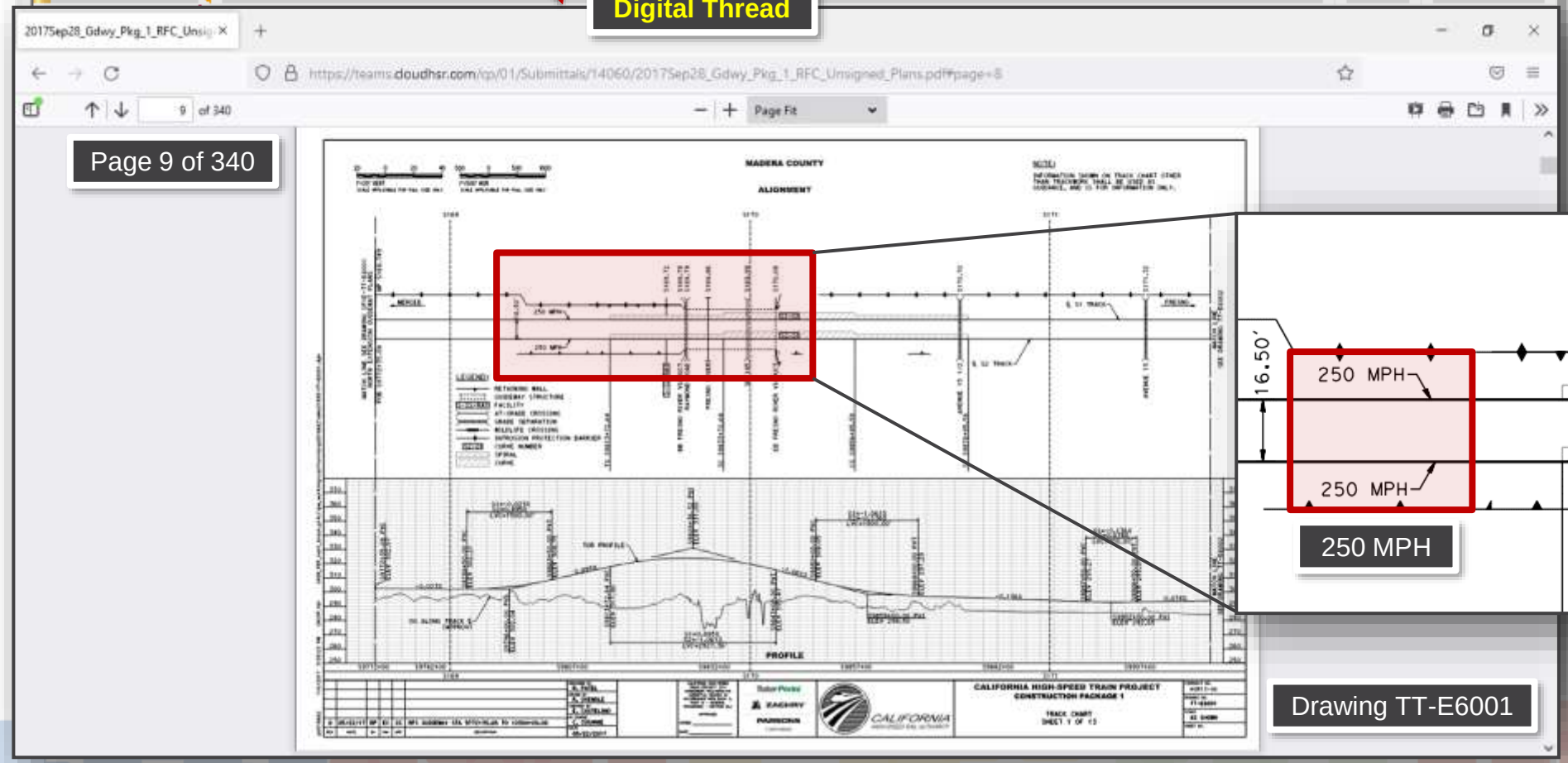
SoSE Activities Performed

Performance Req. Example: Step 6 – Objective Evidence

Drawing #	Drawing Name	Rev	Page #
GE-D0001	COVER SHEET	0	1
...	...		
TT-D0001	TRACK GUIDEWAY - HORIZONTAL ALIGNMENT DATA TABLE	0	8
TT-E6001	TRACK CHART - SHEET 1 OF 13	0	9
TT-E6002	TRACK CHART - SHEET 2 OF 13	0	10
TT-E6003	TRACK CHART - SHEET 3 OF 13	0	11

Digital Thread

Page 9 of 340



Drawing TT-E6001


Tutor Perini | ZACHRY | PARSONS, A Joint Venture

Verification and Validation Certification of Compliance

Submittal Identification	
Project Name:	California High Speed Rail Train Project, CP1
Project Number:	HSR13-06
Document Title:	Guideway Station 9772+35.08 to 10304+00.00 Ready for Construction
Date:	09/11/2017

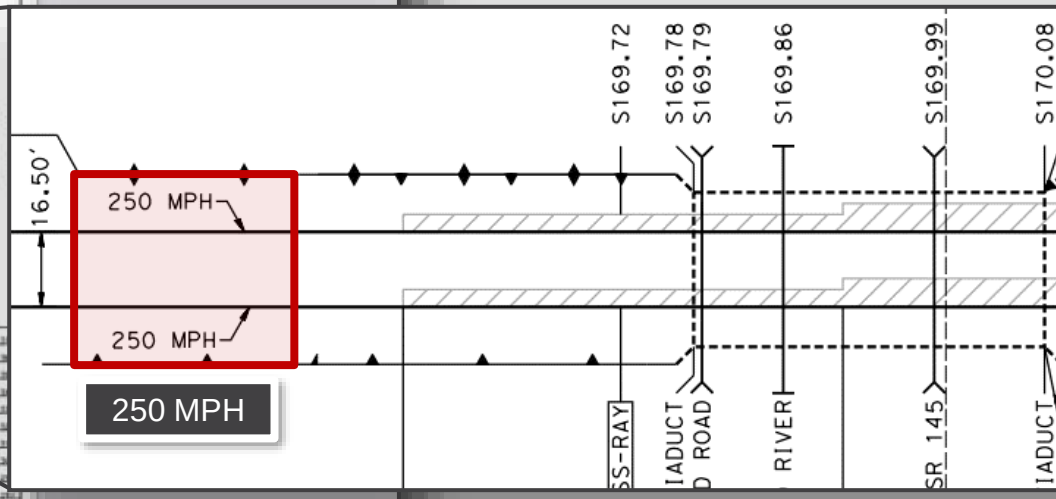
Submittal Verification Status	
Prepared By:	
Verified By:	
Signed off by V & V Manager:	
Date:	

The TPZP V&V team has reviewed and assessed the contract documents including Attachment 8 for all Ready for Construction (RFC) submittals.

The TPZP V&V team confirms that, with the inclusion of the Ready for Construction Certification, all comments received during the 90% Design Submittal review, Submittal reference SW04.11.03-034 have been satisfactorily resolved and verified by the Design Lead and are represented in the RFC Submittal herein. The submittal is complete, contains the required documents inclusive of manuals, reports, drawings, procedures, policies, permits, and agreements to demonstrate compliance of this RFC submittal with the Technical Contract Requirements.

TPZP therefore self-certifies the submittal for Guideway Station 9772+35.08 to 10304+00.00 Ready for Construction to be compliant with Contract Requirements and fitness for purpose.

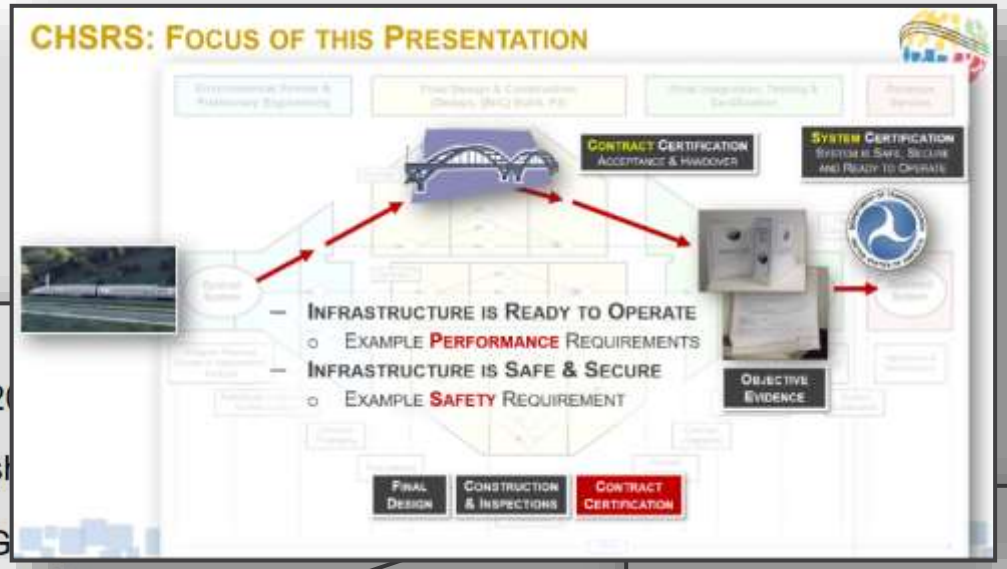
Submittal Certification of Compliance (CoC)



250 MPH

SoSE Activities Performed

Verification, Validation & Certification



Submittal Certification of Compliance (CoC)

27 ***2.2.3.6 Operating and Design Speed***

28 The CHSR System operating speed shall be 22(

29 In areas of shared-use track, operating speed sl

30 • Peninsula Corridor from San Francisco to G

31 • Burbank to Anaheim project section in Phase 1 of the project

32 • Los Angeles to San Diego in the Phase 2 of the project

33 The System design speed shall be 250 mph.

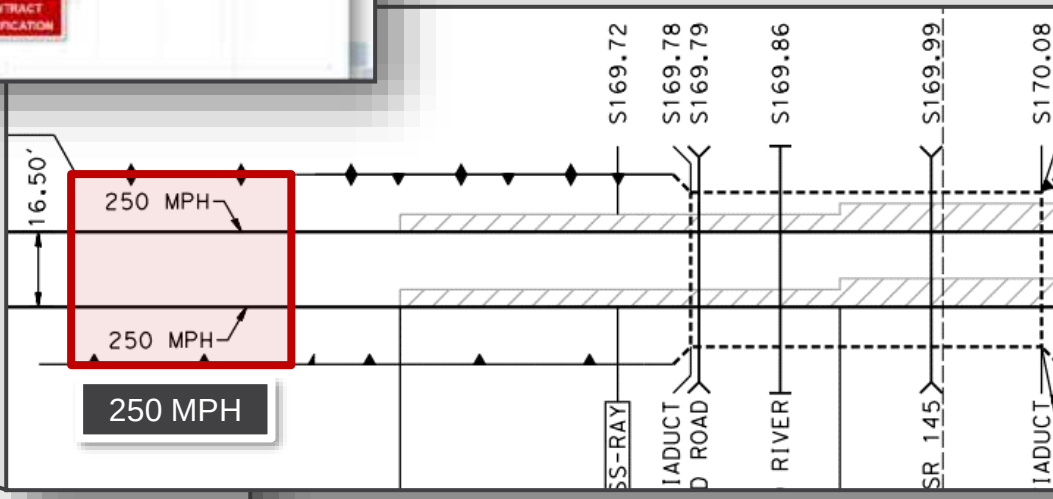
34 In areas of shared-use track, design speed shall be as follows:

35 • Peninsula Corridor from San Francisco to Gilroy: 110 mph

36 • Burbank to Anaheim project section in Phase 1 of the project: 125 mph

37 • Los Angeles to San Diego in Phase 2 of the project: 125 mph

38 The CHSR System design shall incorporate the needs for a testing speed of at least 110 percent of the
39 operating speed.



Trust but Verify using **Digital Threads**

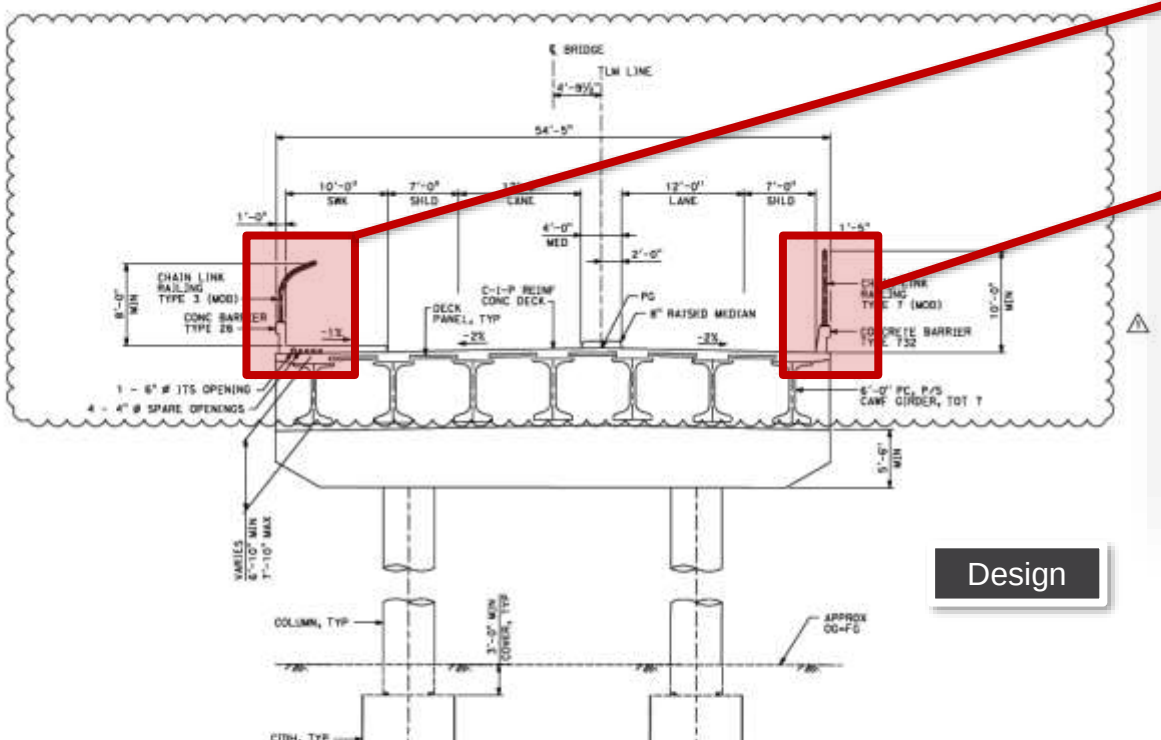
SoSE Activities Performed

Safety Req. Example (Critical Item -> Certifiable Items List [CIL])

ID	Hazards & Mitigations	CI
1	**1 Infrastructure**	No
2	**1.1 R-O-W Generally**	No
12	**1.1.2 Collision**	No
26	**1.1.2.7 Object thrown from overpass**	No
176	**1.1.2.7.1 Mitigation #1**	Yes
	[1] INF:	

Risk of Thrown Objects

Install intrusion prevention fencing at overpasses.

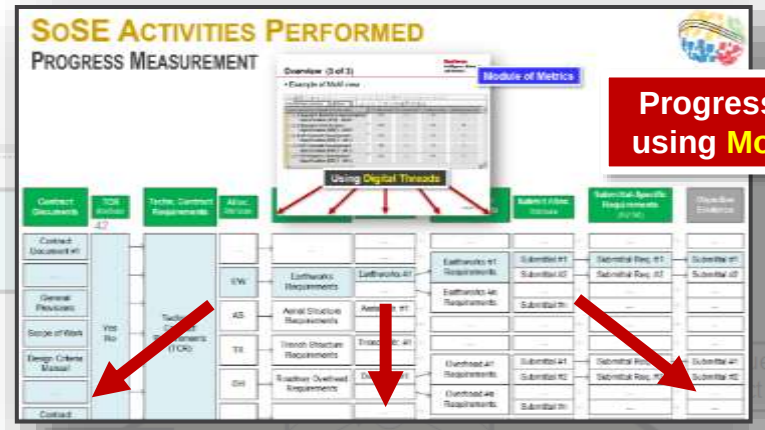


Design

Construction

SoSE Activities Performed

Progress Measurement



Progress Measurement using Module of Metrics

Environmental Review & Preliminary Engineering

Final Integration, Testing & Certification

Revenue Service

Contract 1

Contract

Contract n

Black Box Approach, Defined Interfaces, Project Specific Implementation

Demonstration of Compliance (V&V)

Individual Project Requirements

Contract Packaging

Contract Integration

Certifications with Supporting Evidence

SoSE Activities Performed

Module of Metric (MoM) – Inspiration

Raytheon
Customer Success Is Our Mission

2013 IBM Webinar

AIR
LAND
SEA
SPACE
CYBER

DOORS® Module of Metrics (MoM) Approach

Jerry Huller
Senior Principal Systems Engineer
15 November 2013

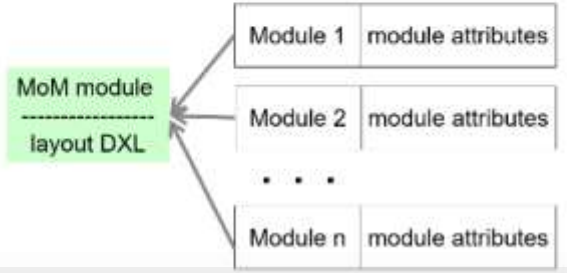
Overview (2 of 3)

Raytheon
Intelligence, Information and Services

- Basic concept:
  - Create module level DXL attributes that can provide desired data, equivalent to running a simple or compound filter query in DOORS

    Create once and copy to all requirement modules

  - Use layout DXL to "pull" the attribute values into a master module called the Module of Metrics (MoM), which is accessible at any time by any DOORS user

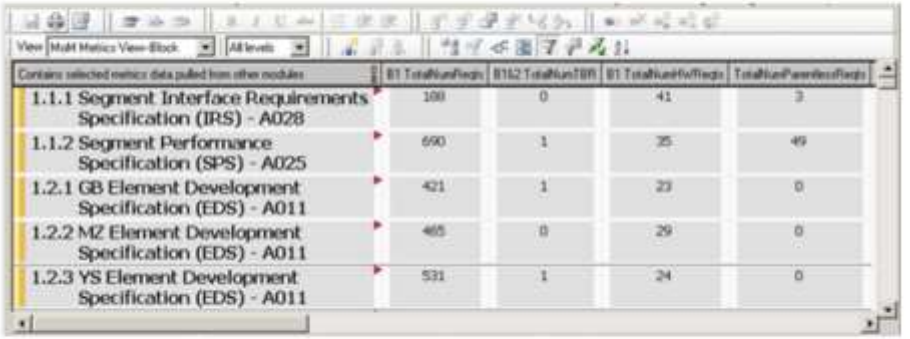


11/15/2013 | 5

Overview (3 of 3)

Raytheon
Intelligence, Information and Services

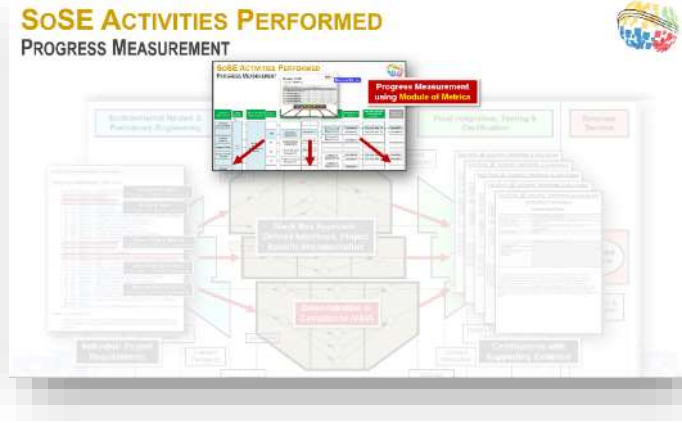
- Example of MoM view



Contains selected metrics data pulled from other modules	B1 TotalNumReqts	B1&2 TotalNumTBRs	B1 TotalNumFlwReqts	TotalNumParentlessReqts
1.1.1 Segment Interface Requirements Specification (IRS) - A028	100	0	41	3
1.1.2 Segment Performance Specification (SPS) - A025	690	1	35	49
1.2.1 GB Element Development Specification (EDS) - A011	421	1	23	0
1.2.2 MZ Element Development Specification (EDS) - A011	465	0	29	0
1.2.3 YS Element Development Specification (EDS) - A011	531	1	24	0

SoSE Activities Performed

High-Speed Rail MoM



Raytheon
Intelligence, Information and Services

Overview (3 of 3)

- Example of MoM view

Contains selected metrics data pulled from other modules	B1 TotalNumReqts	B1&2 TotalNumTBR	B1 TotalNumHWReqts	TotalNumParentlessReqts
1.1.1 Segment Interface Requirements Specification (IRS) - A028	188	0	41	3
1.1.2 Segment Performance Specification (SPS) - A025	690	1	35	49
1.2.1 GB Element Development Specification (EDS) - A011	421	1	23	0
1.2.2 MZ Element Development Specification (EDS) - A011	465	0	29	0
1.2.3 YS Element Development Specification (EDS) - A011	531	1	24	0

11/15/2013

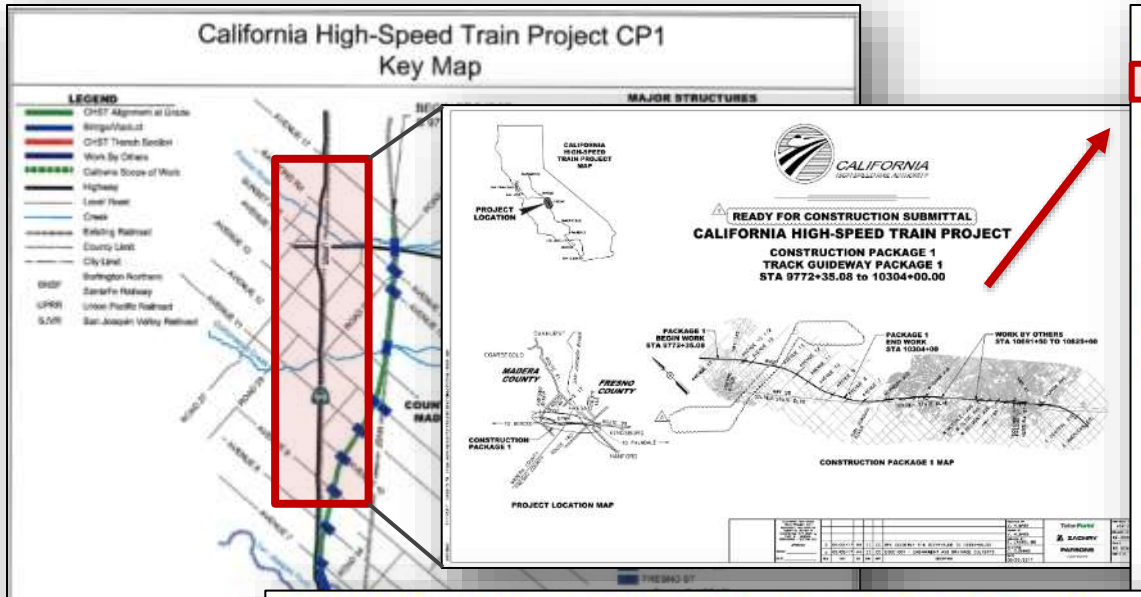
Using Digital Threads

Module of Metrics

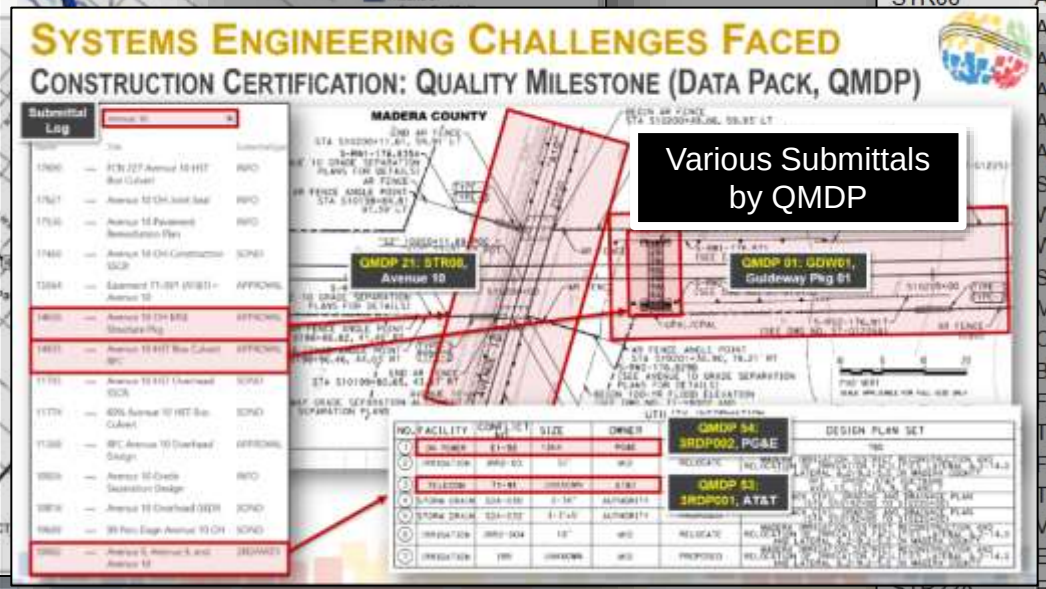
Contract Documents	TCR Attribute	Techn. Contract Requirements	Alloc. Attribute				Submit Alloc. Attribute	Submittal-Specific Requirements (RVTM)	Objective Evidence
Contract Document #1	Yes No	Technical Contract Requirements (TCR)	...	...	...	...	...	...	...
...					...				
General Provisions			EW	Earthworks Requirements	Earthworks #1	Earthworks #1 Requirements	Submittal #1	Submittal Req. #1	Submittal #1
Scope of Work							Submittal #2	Submittal Req. #2	Submittal #2
Design Criteria Manual					...	Earthworks #n Requirements	...	...	...
...			AS	Aerial Structure Requirements	Aerial Str. #1		Submittal #n	...	...
Contract					...	...	...	...	...
			TR	Trench Structure Requirements	Trench Str. #1	...	...	...	...
					...	Overhead #1 Requirements	Submittal #1	Submittal Req. #1	Submittal #1
			OH	Roadway Overhead Requirements	Overhead #1		Submittal #2	Submittal Req. #2	Submittal #2
					...	Overhead #n Requirements	...	...	...
					...		Submittal #n	...	...

SoSE Activities Performed

Defining the 100% Contract Certification Scope (by QMDP)



CP1 Structures



Various Submittals by QMDP

Milestones & the Field Engineers responsible for them

GDW01	MADERA COUNTY GUIDEWAY - Litto
GDW02	SJRV TO FRESNO TRENCH GUIDEWAY - Lit
GDW03	N AVENUE
NE01	
NE02	SCHMIDT CREEK HST - Katrina
NE03	SCHMIDT CREEK CULVERT BOX - Katrina
NE04	WILDLIFE CROSSING MP167.4 - Katrina
NE05	ROAD 27 - Katrina
NE 06	AVE 17 - Katrina
STR01	FRESNO RIVER VIADUCT (FRV) - Gavin
STR02	AVENUE 15-1/2 OH - Katrina
STR03	AVENUE 15 OH - Katrina
STR04	COTTONWOOD CREEK BR - Katrina
STR05	AVENUE 12 HST OH - Katrina
STR06	AVENUE 12 BNSF OH - Katrina
	AVENUE 11 OH - Katrina
	AVENUE 10 OH - Katrina
	AVENUE 9 OH - Katrina
	AVENUE 8 OH - Katrina
	AVENUE 7 OH - Katrina
	SAN JOAQUIN RIVER VIADUCT (SJRV) - Dou
	W HERNDON AVE HST OP - Doug
	W HERNDON AVE UPRR OP - Doug
	SHAW AVENUE OH – Sri
	MCKINLEY AVENUE OH – Sri
	OLIVE AVENUE OH – Sri
	BELMONT AVENUE OH – Sri.
	FRESNO TRENCH Tyler B
	TUOLUMNE STREET OH – Matt K
	FRESNO STREET UP - Gavin
	TULARE STREET UP - Gavin
	VENTURA AVENUE UP - Gavin
	E CHURCH AVENUE HST - Gavin
	E CHURCH AVENUE BNSF OH - Gavin
STR22A	
STR23	JENSEN TRENCH Tyler B

QMDP 01: GDW01 Guideway Package 01

STR 24B	E MUSCAT AVE HST - Gavin
STR25	CENTRAL AVENUE OH - Gavin
STR26	AMERICAN AVENUE OH - Gavin
3RDP001	AT&T - Juan
3RDP002	PG&E - Bianca
3RDP003	CITY OF FRESNO - Bennie
3RDP004	COUNTY OF FRESNO - Bennie
3RDP005	COUNTY OF MADERA - Bennie
3RDP006	UPRR - Addison
3RDP007	BNSF - Addison
3RDP008	CALTRANS - Bennie
3RDP009	MADERA IRRIGATION DISTRICT - Greg
3RDP010	FRESNO IRRIGATION DISTRICT - Greg
3RDP011	FMFCD - Greg
3RDP012	KINDER MORGAN - Addison
3RDP013	LEVE III - Addison
3RDP014	COMCAST - Addison
3RDP015	SPRINT - Addison
3RDP016	TW TELECOM - Addison
3RDP017	TIME WARNER- Addison
3RDP018	QWEST - Addison
3RDP019	CVIN - Addison
3RDP020	SEBATIAN KERMAN TELECOM - Addison
3RDP021	MCI - Addison
3RDP022	SIERRA TELEPHONE - Addison

CP1: **70+ QMDPs** (Quality Milestone Data Packs)

SoSE Activities Performed

CP4 Example: Building the MoM

'Module of Metrics' current 1.2 in /CRB DOORS-DB 2021-01/00_Metrics (Formal module) - DOORS

File Edit View Insert Link Analysis Table Tools Discussions User Change Management Help

View: 12. MoM Export | Level 2

Absolute	Object	_MoM_QMDP	Metrics
54	1		4 Site-Specific Requirements
986	2	QMDP 01	4.1 QMDP 01
987	2	QMDP 02	4.2 QMDP 02
988	2	QMDP 03	4.3 QMDP 03
989	2	QMDP 04	4.4 QMDP 04
991	2	QMDP 05	4.5 QMDP 05
992	2	QMDP 06	4.6 QMDP 06
993	2	QMDP 07	4.7 QMDP 07
1050	2	QMDP 08	4.8 QMDP 08
994	2	QMDP 09	4.9 QMDP 09
995	2	QMDP 10	4.10 QMDP 10
996	2	QMDP 11	4.11 QMDP 11
997	2	QMDP 12	4.12 QMDP 12
998	2	QMDP 13	4.13 QMDP 13
999	2	QMDP 14	4.14 QMDP 14
1000	2	QMDP 15	4.15 QMDP 15
1001	2	QMDP 16	4.16 QMDP 16
1002	2	QMDP 17	4.17 QMDP 17
1003	2	QMDP 18	4.18 QMDP 18
1004	2	QMDP 19	4.19 QMDP 19
1005	2	QMDP 20	4.20 QMDP 20
1006	2	QMDP 21	4.21 QMDP 21
1007	2	QMDP 22	4.22 QMDP 22
1008	2	QMDP 23	4.23 QMDP 23
1009	2	QMDP 24	4.24 QMDP 24
1010	2	QMDP 25	4.25 QMDP 25
1011	2	QMDP 26	4.26 QMDP 26
1012	2	QMDP 27	4.27 QMDP 27
1013	2	QMDP 28	4.28 QMDP 28

Contractor QMDP Plan

#	Activity ID	QMDP #	Activity Name	Stationing	Responsible
1	MIL_1285	QMDP 01	EOP to County Line	14769+23 - 14822+00	North S.M.
2	MIL_1290	QMDP 02	County Line to S Scofield	14822+00 - 14877+00	North S.M.
3	MIL_1295	QMDP 03	S Scofield to Garces Abut1	14877+00 - 14931+21	North S.M.
4	MIL_1145	QMDP 04	Garces Hwy Underpass	14931+31 - 14932+23	North S.M.
5	MIL_1300	QMDP 05	Garces Abut. 2 to Woollomes Ave	14932+23 - 14989+50	North S.M.
6	MIL_1305	QMDP 06	Woollomes Ave to Pump Station	14989+50 - 15055+00	North S.M.
7	MIL_1310	QMDP 07	Pump Stat ion to S. Magnolia	15055+00 - 15096+50	North S.M.
8	MIL_1315	QMDP 08	S. Magnolia to Pond Rd. Abut. #1		
9	MIL_1115	QMDP 09	Pond Rd Underpass		
10	MIL_1320	QMDP 10	Pond Rd. Abut. 2 to Peterson Rd. A		
11	MIL_1155	QMDP 11	Peterson Rd Underpass		
12	MIL_1325	QMDP 12	Peterson Rd. Abut. 1 to Elmo Hwy		
13	MIL_1330	QMDP 13	Elmo Hwy to Sherwood Ave		
14	MIL_1335	QMDP 14	Sherwood Ave to Poso Creek Abut		
15	MIL_1105	QMDP 15	Poso Creek Overpass		
16	MIL_1340	QMDP 16	Poso Creek Abut. 1 to Taussig Ave.		
	MIL_1345	QMDP 17	Taussig Ave to Canal 9-22		
	MIL_1350	QMDP 18	Canal 9-22 to McCombs Ave.		
	MIL_1185	QMDP 19	McCombs Ave Overpass		
20	MIL_1355	QMDP 20	McCombs Ave.to SR-46 Abut. 1		
21	MIL_1095	QMDP 21	SR 46 Underpass	15560+89 - 15562+12	South S.M.
22	MIL_1360	QMDP 22	SR-46 Abut. 1 to Pedestrian Underpass	15563+00 - 15587+00	South S.M.
23	MIL_1085	QMDP 23	HST Pedestrian Underpass	15588+25 - 15590+25	South S.M.
24	MIL_1365	QMDP 24	Pedestrian Underpass to Poso Ave	15590+00 - 15614+00	South S.M.
25	MIL_1195	QMDP 25	Poso Ave Underpass	15613+83 - 15614+43	South S.M.
26	MIL_1370	QMDP 26	Poso Ave to Wasco Viaduct Abut. 1	15614+00 - 15660+00	South S.M.
27	MIL_1270	QMDP 27	Wasco Viaduct	15660+20 - 15679+73	South S.M.
28	MIL_1375	QMDP 28	Wasco Viaduct Abutment 11 to Kimber	15660+00 - 15720+00	South S.M.

SoSE Activities Performed

CP4 Example: Submittals by QMDP, Measuring Progress

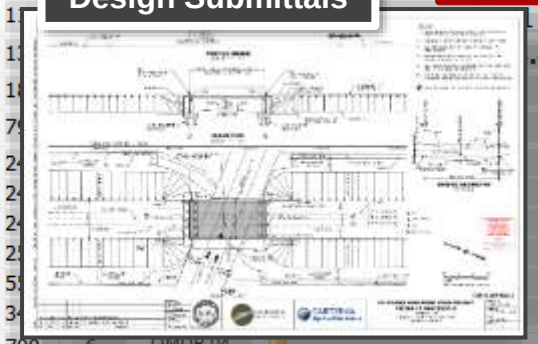
'Module of Metrics' current 1.2 in /CRB DOORS-DB 2021-01/00_Metrics (Formal module) - DOORS

File Edit View Insert Link Analysis Table Tools Discussions User Change Management Help

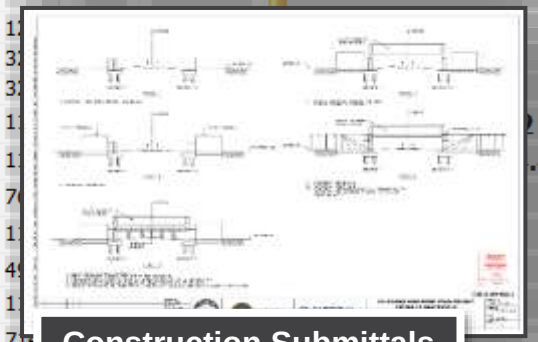
View: 12. MoM Export | Level 7

Absolute	Object	_MoM_QMDP	Metrics	_MoM_RDC	_MoM_HSR_3RD	Submittal Date	SONO/APP Date	Linked Module	Linked Ol
54	1		**4 Site-Specific Requirements**			-	-	-	-
989			**4.4 QMDP 04**			-	-	-	-
1			**High-Speed Rail**		HSR	-	-	-	-
1			**4.4.1 HSR Aerial Structure**		HSR	-	-	-	-
1			**4.4.1.1.1 Garces**		HSR				-
7			4.4.1.1.1.1 Design	Design	HSR				-
2			**Type Selection Report (TSR)**	Design	HSR	05 June 2017	16 June 2017	01 Civil Evidence Module	5.2 TSI
2			**Geotechnical Engineering Design Report (GEDR)**	Design	HSR	23 January 2019	27 April 2017	01 Civil Evidence Module	5.1 GEI
2			**60% Design**	Design	HSR	19 June 2017	06 November 2017	01 Civil Evidence Module	5.3 60%
2			**90% Design**	Design	HSR	18 December 2017	26 February 2018	01 Civil Evidence Module	5.4 90%
5			**Ready for Construction (RFC)**	Design	HSR	12 March 2019	19 November 2018	01 Civil Evidence Module	5.5 RFC
3			**Bearings: Design Calcs**	Design	HSR	22 January 2019	23 May 2019	01 Civil Evidence Module	19.1 Ga
799	6	QMDP 04	4.4.1.1.1.2 Construction	Construction	HSR	-	-	-	-
1			**Construction Stage 1: Foundations, Abutments & Bents**	Construction	HSR	-	-	01 Civil Evidence Module	5.6.1 S
3			**Construction Stage 2: Wingwall & Approaches**	Construction	HSR	-	-	01 Civil Evidence Module	5.6.2 S
3			**Construction Stage 3, 4, 5: Superstructure**	Construction	HSR	-	-	01 Civil Evidence Module	5.6.3 S
1			**Third Parties**				-		
1			**4.2.1 Electric Distribution**				-		
7			**4.4.2.1.1 Conflict 12004, PG&E**				-		
1			4.4.2.1.1.1 Design	ign			-	-	-
4			**Issued for Construction (IFC)**	ign		ugust 2018	29 August 2018	02 Utility Evidence Module	2.92 IF
1			4.4.2.1.1.2 Construction	struc			-	-	-
71			**Construction: All Stages**	struct			-	-	-
113			**4.4.2.2 Telecom**				-	-	-
813	5	QMDP 04	**4.4.2.2.1 Conflict 1000, AT&T**			-	-	-	-
1151	6	QMDP 04	4.4.2.2.1.1 Design	ign	Third Party				-
389	7	QMDP 04	**Ready for Construction (RFC)**	ign	Third Party			02 Utility Evidence Module	1.30 RF
1152	6	QMDP 04	4.4.2.2.1.2 Construction	Construction	Third Party	-	-	-	-

Design Submittals



Construction Submittals



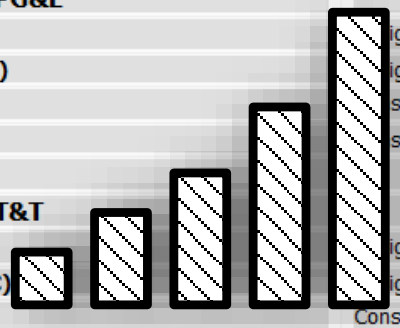
Planned Work

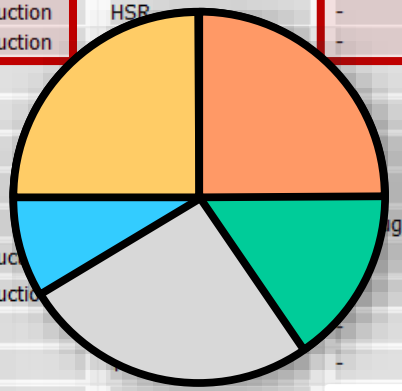
Completed Work

Submittal Dates

Acceptance Dates

Information Retrieved from Contractor RM Tool Database





Achieved Progress

SoSE Activities Performed

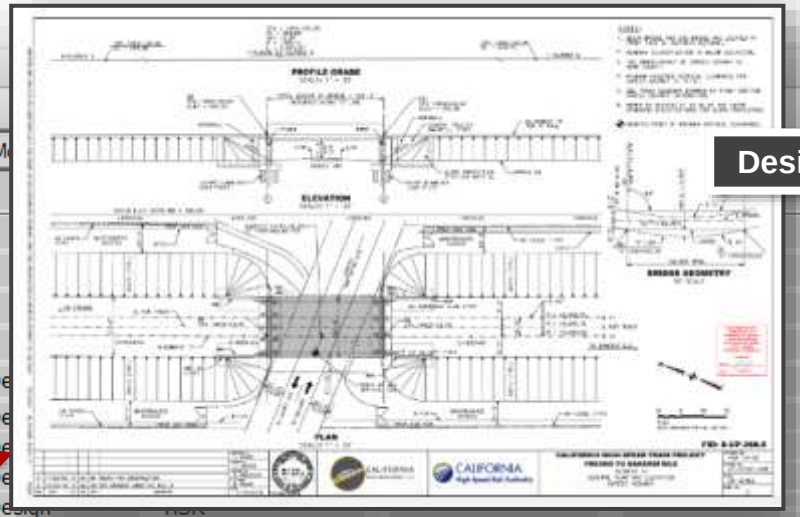
CP4 Example: Using the Digital Threads

'Module of Metrics' current 1.2 in /CRB DOORS-DB 2021-01/00_Metrics (Formal module) - DOORS

File Edit View Insert Link Analysis Table Tools Discussions User Change Management Help

View: 12. MoM Export | All levels

Absolute	Object	_MoM_QMDP	Metrics	Linked Ol
54	1		**4 Site-Specific Requirements**	-
989	2	QMDP 04	**4.4 QMDP 04**	-
1133	3	QMDP 04	**4.4.1 High-Speed Rail**	-
130	4	QMDP 04	**4.4.1.1 HSR Aerial Structure**	-
181	5	QMDP 04	**4.4.1.1.1 Garces**	-
798	6	QMDP 04	4.4.1.1.1.1 Design	-
247	7	QMDP 04	**Type Selection Report (TSR)**	01 Civil Evidence Module 5.2 TSR
248	7	QMDP 04	**Geotechnical Engineering Design Report (GEDR)**	01 Civil Evidence Module 5.1 GEDR
628	8	QMDP 04	SS.AS.GARCES.GEDR.RVTM	01 GEDR Garces_RVTM -
627	8	QMDP 04	SS.AS.GARCES.GEDR.CIL	01 GEDR Garces_CIL -
249	7	QMDP 04	**60% Design**	
250	7	QMDP 04	**90% Design**	
55	7	QMDP 04	**Ready for Construction (RFC)**	
15	8	QMDP 04	SS.AS.GARCES.RFC.RVTM	
14	8	QMDP 04	SS.AS.GARCES.RFC.CIL	
807	8	QMDP 04	SS.AS.GARCES.RFC.COC	
349	7	QMDP 04	**Bearings: Design Calcs**	
88	8	QMDP 04	SS.AS.GARCES.BEA.RVTM	
809	8	QMDP 0		
799	6	QMDP 0		
129	7	QMDP 0		
59	8	QMDP 0		
58	8	QMDP 0		
320	7	QMDP 0		
321	7	QMDP 0		
808	8	QMDP 0		
3364	8	QMDP 0		
1128	3	QMDP 0		
1131	4	QMDP 0		
760	5	QMDP 0		



Design Submittals

California High-Speed Rail Construction Package 4

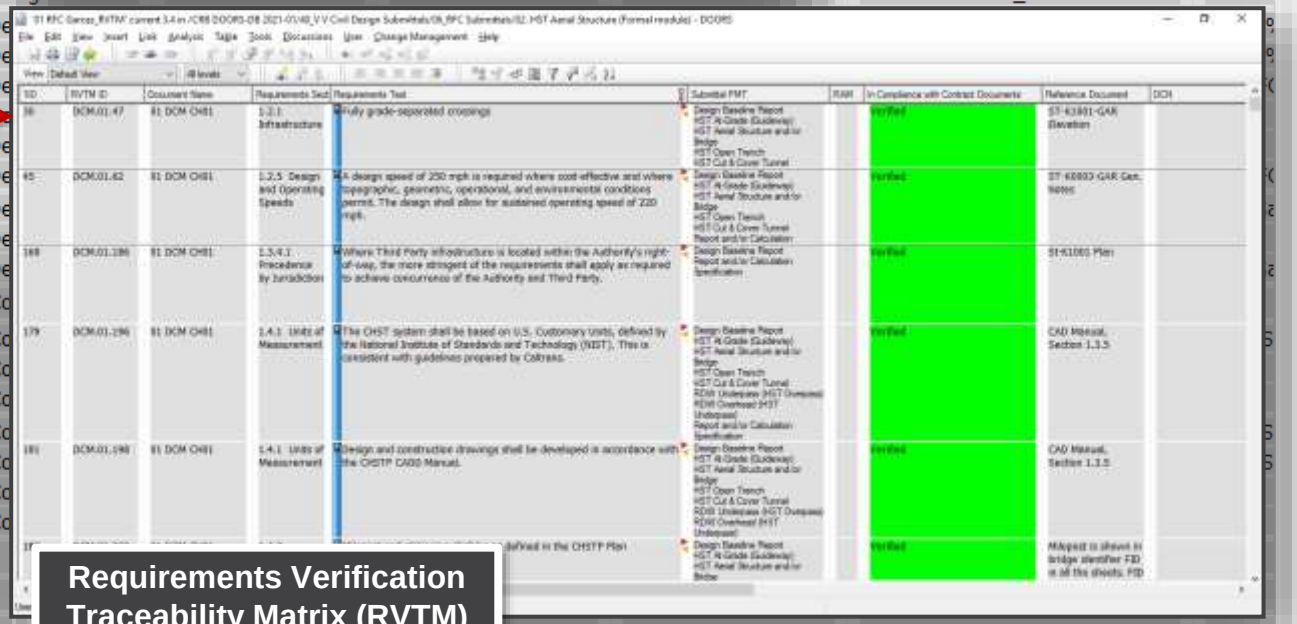
CALIFORNIA RAILBUILDERS

V&V Report for RFC Design Drawings for HSR Structure over Garces Highway	Revision:	04
Doc No.: CP4-6.16.2.1-0002	Date:	3/12/2019

2. CERTIFICATE OF COMPLIANCE WITH TECHNICAL CONTRACT REQUIREMENTS

This certification of compliance includes the confirmation by the Contractor's V&V Manager, as per the VVSC section 2.3.4 and 3.1, that the work described in this submittal is in compliance with the Technical Contract Requirements and fitness for purpose and that the references to the objective evidence provided in the RVTM [illegible] checked by the Contractors QA/QC process, and have been confirmed as

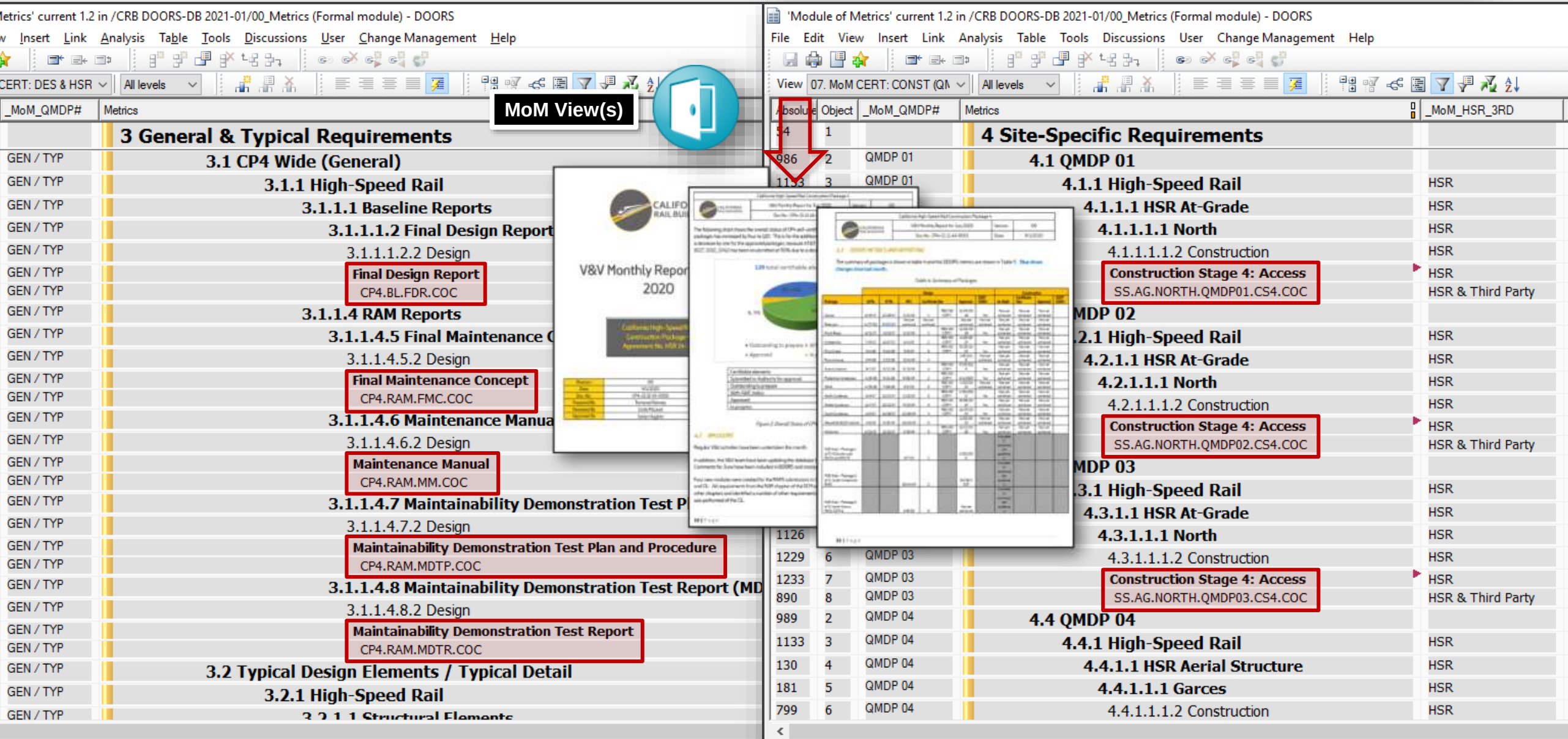
Certificate of Compliance (CoC)



Requirements Verification Traceability Matrix (RVTM)

SoSE Activities Performed

CP4 Example: Reporting Certificates of Compliance (CoC) Progress



SoSE Activities Performed

CP4 Example: Safety & Security Certification Reports (SSCR) Progress

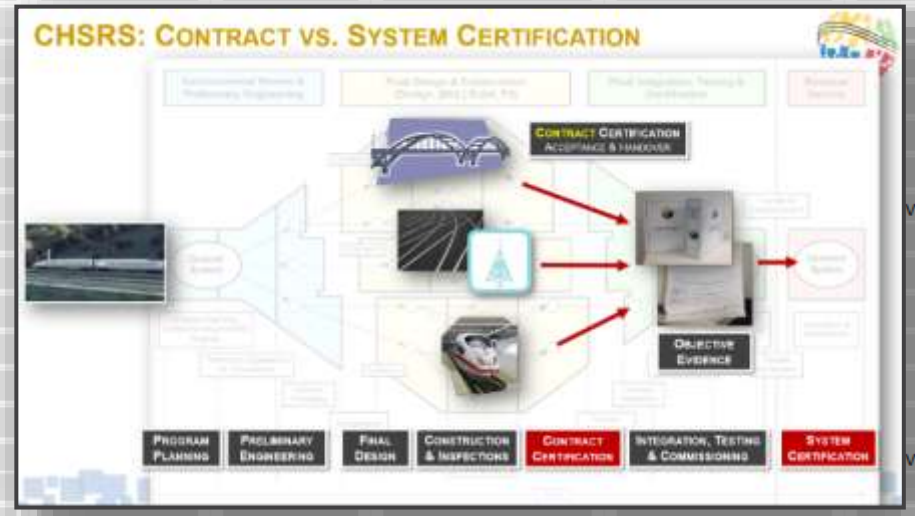
'Module of Metrics' current 1.2 in /CRB DOORS-DB 2021-01/00_Metrics (Formal module) - DOORS

File Edit View Insert Link Analysis Table Tools Discussions User Change Management Help

View: 08. MoM S&S: CONST (SSC | All levels

Absolute	Object	_MoM_QMDP#	Metrics	_MoM_HSR_3RD	_MoM_RDC	_MoM_Cert	Submittal Date	SONO/APP Date	Linked Module
54	1		**4 Site-Specific Requirements**				-	-	-
986	2	QMDP 01	**4.1 QMDP 01**				-	-	-
1153	3	QMDP 01	**4.1.1 High-Speed Rail**	HSR			-	-	-
6	4	QMDP 01	**4.1.1.1 HSR At-Grade**	HSR			-	-	-
46	5	QMDP 01	**4.1.1.1.1 North**	HSR			-	-	-
797	6	QMDP 01	4.1.1.1.1.2 Construction	HSR	Construction		-	-	-
315	7	QMDP 01	**Construction Stage 4: Access**	HSR	Construction		-	-	01 Civil Evidence Module
3358	8	QMDP 01	SS.AG.NORTH.QMDP01.CS4.SSCR	HSR & Third Party	Construction		-	-	-
989	2	QMDP 04	**4.4 QMDP 04**						
1133	3	QMDP 04	**4.4.1 High-Speed Rail**	HSR					
130	4	QMDP 04	**4.4.1.1 HSR Aerial Structure**	HSR					
181	5	QMDP 04	**4.4.1.1.1 Garces**	HSR					
799	6	QMDP 04	4.4.1.1.1.2 Construction	HSR					
321	7	QMDP 04	**Construction Stage 3, 4, 5: Superstructure**	HSR					vil Evidence Module
3364	8	QMDP 04	SS.AS.GARCES.QMDP04.CS3.SSCR	HSR & Third Party					
993	2	QMDP 07	**4.7 QMDP 07**						
1163	3	QMDP 07	**4.7.1 High-Speed Rail**	HSR					
1032	4	QMDP 07	**4.7.1.1 HSR At-Grade**	HSR					
1061	5	QMDP 07	**4.7.1.1.1 North**	HSR					
1063	6	QMDP 07	4.7.1.1.1.2 Construction	HSR					
1647	7	QMDP 07	**Construction Stage 4: Access**	HSR					vil Evidence Module
3359	8	QMDP 07	SS.AG.NORTH.QMDP07.CS4.SSCR	HSR & Third Party					
994	2	QMDP 09	**4.9 QMDP 09**				-	-	-
1167	3	QMDP 09	**4.9.1 High-Speed Rail**	HSR					-
990	4	QMDP 09	**4.9.1.1 HSR Aerial Structure**	HSR					-
133	5	QMDP 09	**4.9.1.1.1 Pond**	HSR					-
845	6	QMDP 09	4.9.1.1.1.2 Construction	HSR	Construction		-	-	-

MoM View(s)

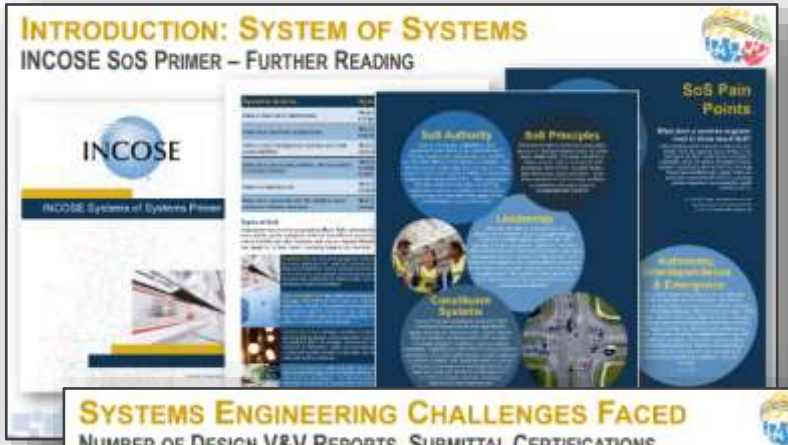


System is Safe, Secure and Ready to Operate

PROGRESS

- **Introduction**
  - Brief System of Systems (SoS) Overview
  - California High-Speed Rail System (CHSRS) Program
  - Use of Digital Threads in the CHSRS Program
- **SoSE Challenges Faced**
  - Systems Engineering Challenges
  - SoS Engineering Challenges
- **SoSE Activities Performed**
  - Certification Strategy
  - Step by Step Process Description
- **Summary, Achieved Outcomes & Conclusion**

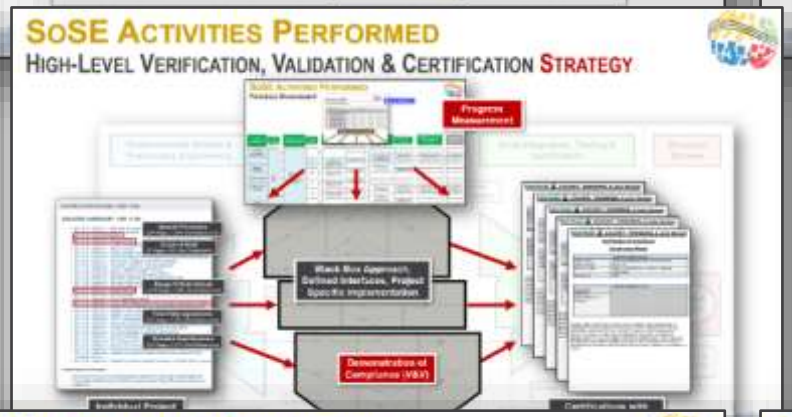
SUMMARY


INTRODUCTION: SYSTEM OF SYSTEMS
INCOSE SOS PRIMER – FURTHER READING
INCOSE
SoS Pain Points

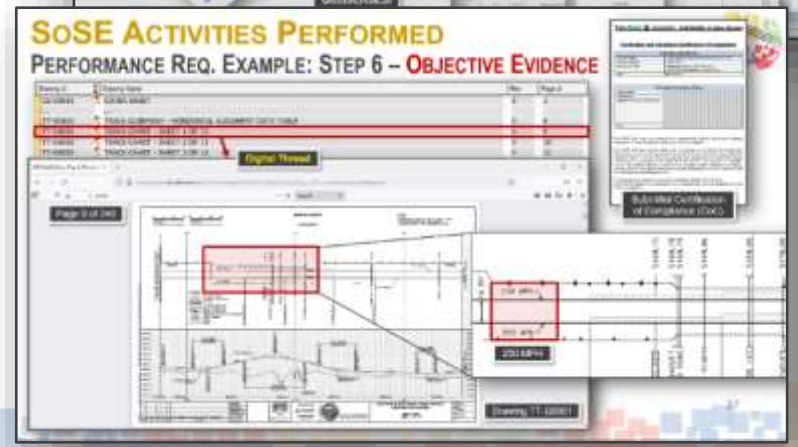

CALIFORNIA HIGH-SPEED RAIL SYSTEM
CHSRS AS A SOS (PROGRAM OF PROJECTS)
Interfacing Systems & Organization
Interfacing Systems & Organization
Project #1
Project #2
Project #n
Program Level
Program Level

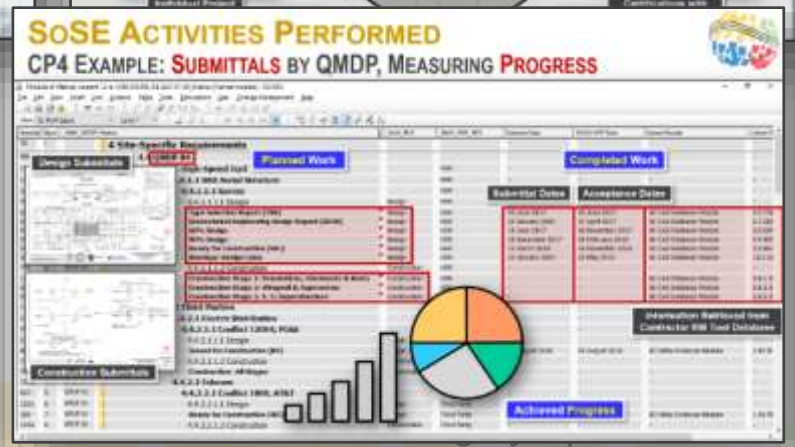

CHSRS: CONTRACT VS. SYSTEM CERTIFICATION
CONTRACT CERTIFICATION
OBJECTIVE EVIDENCE


SYSTEMS ENGINEERING CHALLENGES FACED
NUMBER OF DESIGN V&V REPORTS, SUBMITTAL CERTIFICATIONS
Structural
Civil
Certificates of Compliance
Std. Const. Drwgs.
Retaining Walls
Geotechnical


SOSE ACTIVITIES PERFORMED
HIGH-LEVEL VERIFICATION, VALIDATION & CERTIFICATION STRATEGY
Program Management
Black Box Approach, Defined Interfaces, Project Specific Implementation
Demonstration of Compliance (V&V)


SOSE ACTIVITIES PERFORMED
VERIFICATION & VALIDATION APPROACH: 6 KEY STEPS
Contract
Types
Sites
Submittals


SOSE ACTIVITIES PERFORMED
PERFORMANCE REQ. EXAMPLE: STEP 6 – OBJECTIVE EVIDENCE
Digital Thread
Submittal Certification of Compliance (SSCC)


SOSE ACTIVITIES PERFORMED
CP4 EXAMPLE: SUBMITTALS BY QMDP, MEASURING PROGRESS
Planned Work
Completed Work
Submittal Dates
Acceptance Dates
Achieved Progress


SOSE ACTIVITIES PERFORMED
CP4 EXAMPLE: SAFETY & SECURITY CERTIFICATION REPORTS (SSCR) PROGRESS
Multi View(s)
SYSTEM IS SAFE, SECURE

Achieved Outcomes & Conclusion

- **Large System of Systems**
  - SoS Authority & Leadership: Program verification, validation & certification approach with tailored project type implementation (i.e., civil works, track and systems, trainsets, etc.)
  - SoS Architecture: Program as SoS with projects as constituent systems
  - SoS Autonomous Constituent Systems & Emergence: Projects as black box with defined interfaces: inputs (requirements) & outputs (construction certifications)
- **Use of Digital Threads enables Convenient Access to:**
  - Technical contract requirements and critical items (i.e., RVTMs, CILs)
  - Design & construction submittals and individual submittal files (drawings, calculations, etc.)
  - Design & construction certifications (e.g., CoCs)
  - Safety and security certifications (e.g., SSCRs)
- **System Certification**
  - Trust but verify: Provision of certifications and supporting objective evidence
- **Conclusion**
  - Verification, validation & certification provides high transparency and trust that the final California High-Speed Rail System will be **Safe, Secure, and Ready to Operate**.

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hybrid event

Detroit, MI, USA
June 25 - 30, 2022

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