Project Planning

DUNE Timing System Review

21 July 2020

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Overview

- Personnel
- Deliverables
- Milestones
- Schedule
- Costs
- Risks

- EDMS Documents
  - https://edms.cern.ch/file/2397439/1/DUNE_Timing_System_Procurement_Plan.pdf
  - https://edms.cern.ch/file/2397879/1/timing_system_costs_fdr_july2020.xlsx
  - https://edms.cern.ch/file/2397880/1/DUNE-DAQ-Timing-RiskRegister_v1-1.xlsx

Personnel

University of Bristol

- **David Cussans** (Research Fellow 25%)
  - Project manager, *UK project engineer*
- **Stoyan Trilov** (Research Associate 100%)
  - Firmware/software/commissioning
- **Freddy Fuentes** (E. Engineer 100%)
  - Electronics/firmware design
- **New Hire** (E. Engineer 20%)
  - Electronics/firmware design
- **Keith Clark** (M. Engineer 10%)
  - Mechanical design
- **Sudan Paramesvaran** (Faculty 10%)
  - Commissioning
- **Jim Brooke** (Faculty 10%)
  - Software, *Upstream DAQ convenor*

University of Pennsylvania

- **Jon Sensenig** (E. Engineer)
  - Electronics design
- **Godwin Mayers** (E. Engineer)
  - Electronics design
- **Josh Klein** (Faculty)
- **Rick Van Berg** (Faculty)

- % FTE shown for *Timing System* activities

Deliverables

Category	Item	Description
Production system	D1	Surface GPS system hardware (x2 sets)
	D2	SP Module Timing system hardware (x2 modules)
	D3	Accelerator Timing Interface
Integration/test systems	D4	Production test stand (Bristol)
	D5	Integration lab system (FNAL)
	D6	DAQ kit components
Firmware	D7	For custom FPGA boards (GIB, MIB, FIB)
Software	D8	Library + command line tools
Documentation	D9	System + individual components

Project Milestones

	Owner	Milestone	Date
M1	DAQ	Timing system PRR passed	22 Aug 2021
M2	*Timing*	*PDII Timing system installed*	*13 March 2021*
M3	*Timing*	*PDII Timing system FW & SW complete*	*1 May 2021*
M4	DAQ	PDII DAQ/SC installation complete	3 June 2021
M5	*Timing*	*PDII Timing system commissioned*	*1 July 2021*
M6	*Timing*	*Timing system hardware pre-production complete*	*22 Aug 2021*
M7	DAQ	PDII DAQ/SC ready for operations	3 Sep 2021
M8	*Timing*	*Timing system production complete*	*13 Feb 2023*
M9	DAQ	FNAL integration lab commissioned	27 Sep 2023
M10	DAQ	Ready to install surface DAQ/SC equipment	2 April 2024
M11	DAQ	Surface DAQ/SC equipment installed	18 Jun 2025
M12	DAQ	Det #1 ready to install underground equipment	18 July 2025
M13	DAQ	Det #1 underground equipment installed	14 Jan 2026
M14	DAQ	Det #1 DAQ/SC ready for commissioning	30 Jun 2027
M15	DUNE	Det #1 ready for comissioning	13 Nov 2028

Schedule Tasks

- **Hardware production & test**
  - Prototypes & pre-production (Aug ‘20 - Aug ‘21)
  - Production (Aug ‘21 - Feb ‘23)
- **Firmware/software development; in multiple release cycles**
  - PDII (May ‘20 - Aug ‘21)
  - DUNE (Dec ’22 - Jun ‘25)
- **Integration support**
  - DAQ Kit components (July ‘20 - Sep ‘23)
  - FNAL Integration lab (Sep ‘23 - April ‘24)
- **Installation/commissioning**
  - Surface installation (Mar ’25 - Jun ‘25)
  - Det #1 installation (July ‘25 - Jan ‘26)
  - Det #1 readout commissioning (Jan ‘26 - July ‘26)

Prototyping

- **PD-I prototypes**
  - 10x FMC cards produced for DAQ Kit
- **Prototype #1**
  - Already procured all COTS parts for evaluation (see Stoyan's talk)
  - Prototypes of FIB, MIB, GIB all submitted for manufacture ?
- **Prototype #2**
  - Late 2020
  - Revisions based on lab tests
- **Pre-production prototype**
  - Next year – scheduled completion Aug 2021
  - Revisions based on initial PDII experience

Production - Procurement

Item	Estimated lead-time / days
Micro TCA crate.	14
GPS Discipled oscillator	14
GPS Interface Board (GIB)	30
Micro TCA Interface Board (MIB)	30
Micro TCA AMC FMC carriers	20
Fibre Interface Board (FIB)	30

Lead times all $\lesssim$ 1 month
Total test time 1 staff month

Item	Total Number	Time to test each module/ staff-days	Total time to test / staff-days
Micro TCA crate.	6	0.2	1.2
GPS Discipled oscillator	3	0.2	0.6
GPS Interface Board (GIB)	4	1	4
Micro TCA Interface Board (MIB)	7	2	14
Micro TCA AMC FMC carriers	26	0.2	5.2
Fibre Interface Board (FIB)	30	0.1	3
Total time to test (staff days)			28

Integration Support

- Integration tests with endpoint hardware prototypes
  - Cold Electronics (WIB 2), Photon System (DAPHNE), Calibration
  - Will be based on “DAQ Kits”, which will include a Timing FMC
  - Firmware exists, some software development may be needed

- Production testing & integration
  - Minimal timing system required at FNAL Integration lab
  - Production uTCA crate + MIB + FIB
  - Based on early release of production firmware/software

Installation - Surface

- Install two redundant sets of GPS Rx/oscillators + GIB
  - Initially envisaged one set above Ross shaft, one above Yates
    - For maximum redundancy and system uptime
  - Current DUNE planning only has space/power above Ross
  - Reduced redundancy
    - Failures due surface building infrastructure
    - Correlated antenna failure/interference
  - Details of surface organisation are still tbd
    - Rack/antenna locations etc.
- Power/racks/fibres/network are responsibility of infrastructure team

Installation - Underground

- Power/racks/fibres/network are responsibility of infrastructure team
  - Installation will proceed immediately afterwards
- Anticipate 1-day installation per module :
  - Single lift journey
  - Install 2x crates + cards + splitters
  - Connect crate-splitter fibres
  - Check SFP Tx power
  - Verify basic system control functionality with laptop

Commissioning

- Essentially all DAQ/detector commissioning will rely to some extent on distributed clock & timestamps
  - Timing system installed before endpoints
- Commissioning steps
  - Basic system control test during installation
  - Verify surface-underground communication
  - Test endpoint connections as endpoints are installed
    - Assume FIB-endpoint optical fibres are tested by infrastructure team
    - Final test of full optical path only possible once endpoint installed
    - Once optical path verified, test endpoint functionality

Safety

- Electrical safety
  - All underground equipment housed in uTCA crates, which conform to US safety codes
  - GPS receiver/oscillator is commercial and complies to US safety codes
  - GIB will be supplied with low voltage (12V) from external 110->12V adapter, confirming to US codes.
- Laser safety
  - 1000Base-BX SFPs are low power and remain “eye safe”
  - Even if all 5 SFPs coupled to a single fibre are simultaneously enabled

Cost Table

Item		Unit cost (GBP)	N items	Cost (GBP)
uTCA crate (inc chassis + power + MCH + JSM)	COTS	7178	7	50246
GPS disciplined oscillator	COTS	5683	4	22732
GPS Interface board (GIB)	Custom	2081	6	12486
uTCA Interface board (MIB)	Custom	2560	9	23040
Fibre interface board (FIB) inc SFPs	Custom	793	45	35685
uTCA AMC FMC carriers	COTS	1480	45	66600
Fibre splitters (per cavern)	COTS	1753	2	3506
Total (ex VAT)				**213891**
Total (inc VAT)				**256669**

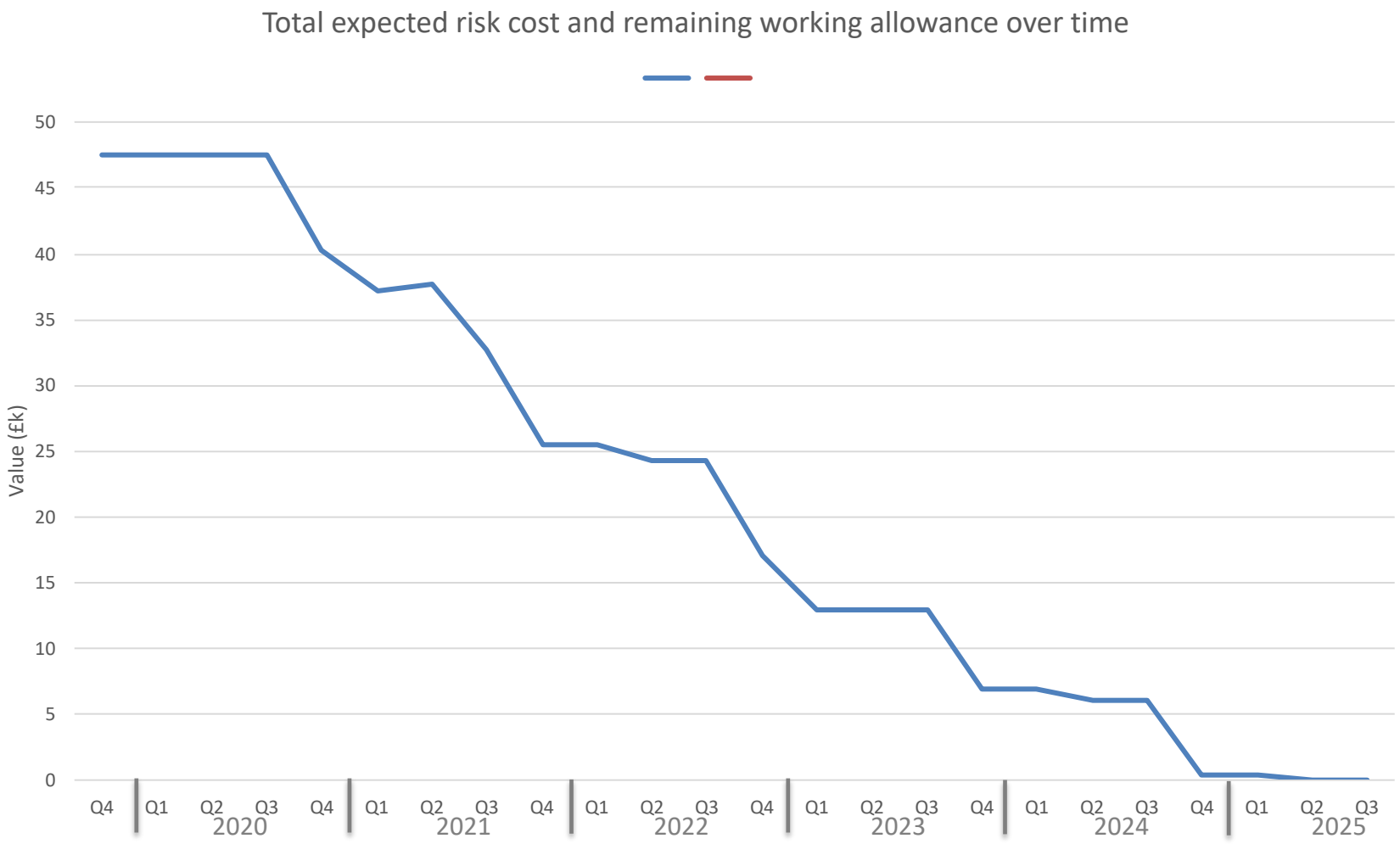
- Production system for two SP FD modules
- ProtoDUNE-II
- FNAL Integration lab
- Vertical slice at Bristol for debugging/development
- Production GIB+MIB at Penn for testing
- *Spares not included above - budget for 10% spares*

Risk Table (Abridged)

0 - 25	Low
25 - 50	Medium
50 - 100	High
0	Retired

Ref	Risk	Potential impact	Existing controls	Mitigation	Residual Risk
1	Concept does not meet requirements	Timing system does not meet all requirements	Design/technical reviews Prototyping at PD, lab tests	Partial/full system redesign	3
2	Requirements incorrect/incomplete	Timing system does not meet the needs of DUNE	Lab tests, tests at ProtoDUNE-2	Review of requirements after ProtoDUNE-2	3
3	Commercial parts obsolete before production	Need to redesign late in cycle	Engineers monitor component availability.	Partial redesign. CDR chip most at risk.	3.5
4	Commercial parts obsolete after production	Higher than expected failure rate leaves system degraded/unrepairable	Acquire sufficient spares before production	Identify at-risk components and increase spares allowance.	4
5	No working firmware	Hardware is unusable	Tests at PDI & PDII	Call in effort from elsewhere in DUNE-UK	7
6	No working software	Hardware is unusable	Tests at PDI & PDII	Call in effort from elsewhere in DUNE-UK	7
7	Control/monitoring API late /unusable	Have to use “hacked up” test scripts to operate system	Tests at PDI & PDII	Monitor progress of CCM carefully	10
8	Cost inaccuracies	Exceed budget	Regular costing updates	Tabulate costs and status of estimate	7.5
9	Currency fluctuations	Highly-correlated risk to project	Tracking affected items	Identify costs in non-£; Explore possibility of buying early	37.5

Risk Projection



Summary

- Personnel available to deliver the system
  - Bristol – HW/FW engineering, SW development, commissioning
  - Penn – HW design
- Key milestones
  - PDII system commissioned : 1 July 2021
  - Production complete : 13 Feb 2023
  - Surface installation complete : 18 Jun 2025
  - Underground installation complete : 14 Jan 2026
  - Ready for operations : 30 Jun 2027
- System cost
  - £257k + 10% spares