REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
01-02-2018	Systems Engineering Plan	Jun 2017-Jun 2019

4. TITLE AND SUBTITLE
Joint Acquisition Task Force Tactical Assault Light Operator Suit Systems Engineering Plan

5a. CONTRACT NUMBER N/A

5b. GRANT NUMBER N/A

5c. PROGRAM ELEMENT NUMBER N/A

6. AUTHOR(S)
MacCalman, Alex

5d. PROJECT NUMBER N/A

5e. TASK NUMBER N/A

5f. WORK UNIT NUMBER N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
United States Special Operations Command
7701 Tampa Point Blvd
MacDill AFB, FL 33621-5323

8. PERFORMING ORGANIZATION REPORT NUMBER
01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION A. Approved for public release: distributed unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The purpose of the Systems Engineering Plan (SEP) is to outline the technical approach for the design development, test, and integration of the Tactical Assault Light Operator Suit (TALOS) system, the United States Special Operations Command's #1 research and development priority. The approach uses a model based, data-driven approach that leverages state-of-the-art System Engineering and Project Management practices in order to facilitate a shared understanding for the TALOS team and partners.

15. SUBJECT TERMS
Systems Engineering, Model-Based Systems Engineering

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Alex MacCalman
U	U	U	UU	44	**19b. TELEPHONE NUMBER** *(Include area code)* 910 797 7144

Reset

Joint Acquisition Task Force Tactical Assault Light Operator Suit

Systems Engineering Plan

COL Alex MacCalman

Chief Engineer

February 2018

Contents

1. Introduction.

The purpose of the Systems Engineering Plan (SEP) is to outline the technical approach for the design development, test, and integration of the Tactical Assault Light Operator Suit (TALOS) system. The approach uses a model based, data-driven approach that leverages state-of-the-art System Engineering and Project Management practices in order to facilitate a shared understanding for the TALOS team and partners. The SEP is a “living” document that specifies the conduct, management, and control of the technical aspects of the TALOS Project.

2. Background.

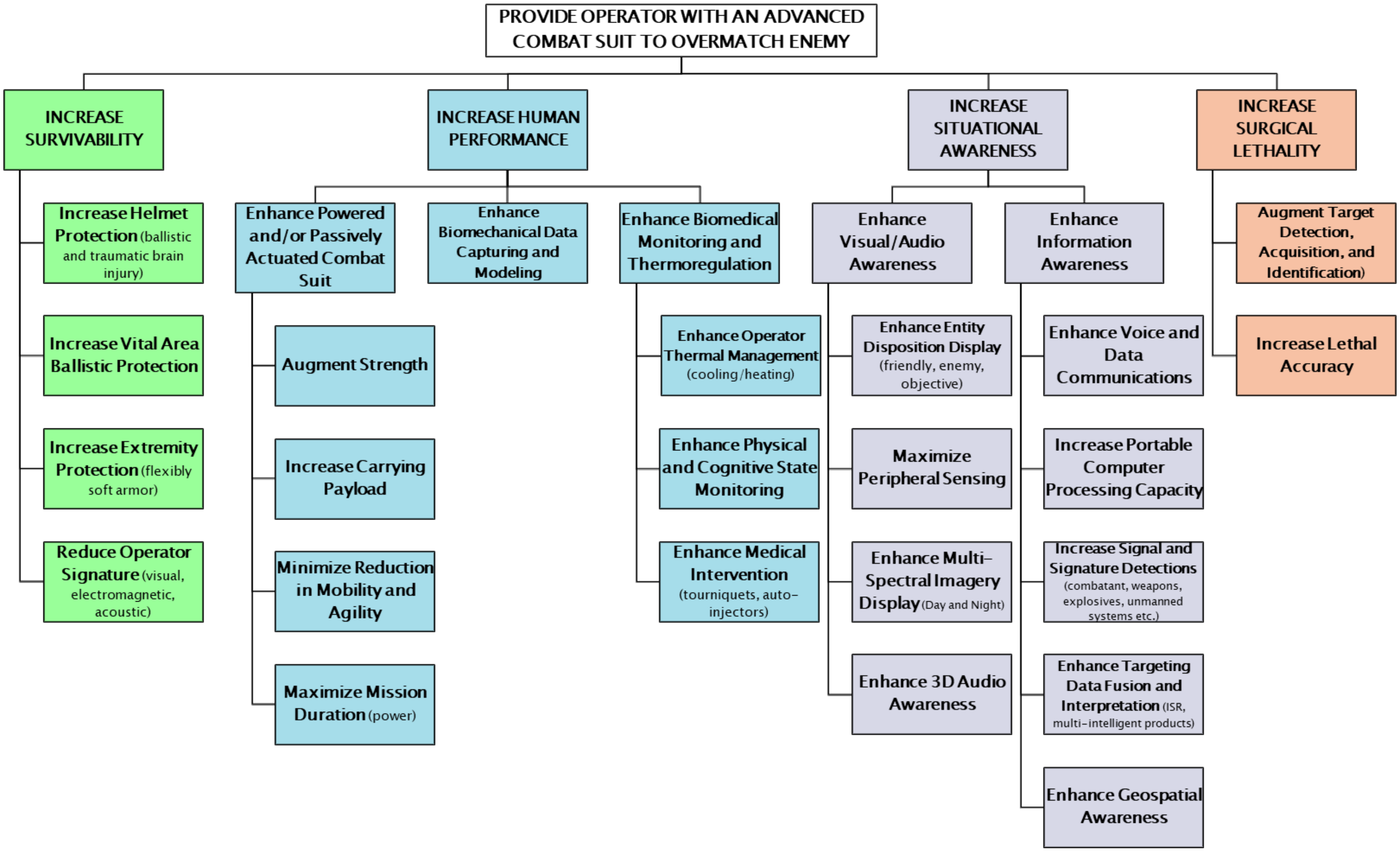
The TALOS Project is a United States Special Operations Command (USSOCOM) initiative with the goal of increasing battlefield survivability, capability, situational awareness and lethality while operating in high risk environments, enabling new mission profiles, addressing historic casualty vulnerabilities, and decreasing the physical and cognitive load on the dismounted SOF operator. USSOCOM Special Operations Forces Acquisition Technology & Logistics (SOF AT&L) will deliver a functional prototype Mark 5 (MK5) Combat Suit in the summer of 2019 that seeks to demonstrate the ability to augment human performance in a Close Quarters Battle (CQB) scenario with a powered, actuated exoskeleton and integrated tactical mission systems. Future variants of TALOS will build upon the technology and lessons learned from the Mk 5 prototype in order to enable operation beyond standard human capability in the most extreme future Direct Action mission profiles by providing enhanced survivability, increased lethality, and dominant situational awareness in order to maintain a global advantage against Near Peer Competitors (NPC) and threats to American national security interests. The Joint Acquisition Task Force (JATF) charter is to revolutionize the technology investment towards the ground combat Special Operations Forces operator. The concept of a JATF is not intended to replicate the work of the Combat Development Directorates or the Program Executive Offices; it is intended to conduct research in science and technology topics that are 5 to 15 years beyond what is achievable in the near term.

3. Joint Acquisition Task Force (JATF) TALOS Vision and Objectives.

The JATF TALOS vision focuses on the following four tenents:

1. Increased Operator ***survivability*** through comprehensive and improved ballistic protection. Develop an exoskeleton that supports near unconstrained movement and provides a load bearing structure.
2. Increased Operator ***capability*** through independently powered actuation of the upper and lower body with integrated biomedical monitoring and thermoregulation to extend thresholds of Human Performance.
3. Increased Operator ***situational awareness*** through visual augmentation, multidimensional display of fused sensors and an integrated array of intelligence and operational data.
4. Increased Operator ***surgical lethality*** by shortening time to target engagement and creating options for novel weapon integration.

In order for the TALOS vision to emerge, each tenant has objectives that serve as the basis for all design, integration, and funding decisions. The figure below shows the TALOS tenent decomposition, which is a decomposed characterization of all the objectives the JATF intends to achieve. Appendix A shows the mapping of each technology area of interest to each of the TALOS objectives.


PROVIDE OPERATOR WITH AN ADVANCED COMBAT SUIT TO OVERMATCH ENEMY
INCREASE SURVIVABILITY
Increase Helmet Protection (ballistic and traumatic brain injury)
Increase Vital Area Ballistic Protection
Increase Extremity Protection (flexibly soft armor)
Reduce Operator Signature (visual, electromagnetic, acoustic)
INCREASE HUMAN PERFORMANCE
Enhance Powered and/or Passively Actuated Combat Suit
Augment Strength
Increase Carrying Payload
Minimize Reduction in Mobility and Agility
Maximize Mission Duration (power)
Enhance Biomechanical Data Capturing and Modeling
Enhance Biomedical Monitoring and Thermoregulation
Enhance Operator Thermal Management (cooling/heating)
Enhance Physical and Cognitive State Monitoring
Enhance Medical Intervention (tourniquets, auto-injectors)
INCREASE SITUATIONAL AWARENESS
Enhance Visual/Audio Awareness
Enhance Entity Disposition Display (friendly, enemy, objective)
Maximize Peripheral Sensing
Enhance Multi-Spectral Imagery Display (Day and Night)
Enhance 3D Audio Awareness
Enhance Information Awareness
Enhance Voice and Data Communications
Increase Portable Computer Processing Capacity
Increase Signal and Signature Detections (combatant, weapons, explosives, unmanned systems etc.)
Enhance Targeting Data Fusion and Interpretation (ISR, multi-intelligent products)
Enhance Geospatial Awareness
INCREASE SURGICAL LETHALITY
Augment Target Detection, Acquisition, and Identification)
Increase Lethal Accuracy

4. TALOS Mark 5 Capability Modules

The TALOS MK5 system is composed of six functional areas that have the following capability modules (CM) and components:

4.1. Exoskeleton (EXO). The EXO CM is designed to power and actuate the exoskeleton to support near unconstrained movement and provide a load bearing structure capable of dynamic activity. The four high level component areas are:

- **Structure.** Titanium and aluminum material support structure to off load weight with ~40 total joints.
- **Actuation.** Geared motors with parallel valved spring to provide powered assistance for 14 joints - Knee (2), hip (4), ankle (2 linear springs), shoulder (4), elbow (2).
- **Control Theory Algorithms**. Match the operator's motion intent such that it is transparent and or enhancing to the operator.
- **Sensor and Control Network.** Sensors and wiring network to measure position and velocity of joints, operators applied force, ground forces, actuator motor output, and to control actuator motor input.

4.2. Power (PWR). The PWR CM is designed to provide power, electrical monitoring and control of the TALOS system. The three high level component areas are:

- **Power Generation System**. The primary path for demonstration is the Advanced Battery Solution. The alternate development path is a Solid Oxide Fuel Cell that will be demonstrated in a lab environment.
- **Power Distribution Manager**. Provides the layer of electrical monitoring, controls and protection.
- **Lab and Insertion Vehicle Tether**. Tethered power source that interfaces with either commercial source or MH-47/60 vehicle.

4.3. Armor (ARM). The ARM CM is designed to increase helmet and body armor for the most common ballistic threat and develops novel armor shapes (curved) to protect against threats better than current Special Operations Forces Personal Equipment Advanced Requirements (SPEAR) plates. Note that the ballistic shell and helmet padding components are managed by the Armor Functional Area Lead (FAL) but are part of the Helmet Assembly. The development efforts in this CM include the following:

- **Ballistic Helmet.** An Ultra-High Molecular Weight Polyethylene (PE) Helmet Shell and Mandible to defeat the most common ballistic threat.
- **Helmet Padding.** Helmet padding to reduce Back-face Deformation to below 20 mm.
- **Armor Plating.** A Ceramic Chest and Lower Abdomen armor plates and an Ultra High Molecular Weight PE armor shell for the power enclosure.
- **Surrogate Armor.** Shape, volume and weight representative plates used for design, integration and demonstration purposes.

4.4. Base Layer (BSL). The BSL CM is designed to manage thermal burden, monitor physiological status, inform exoskeleton control sensing, and provide soft armor and friction protection. The components of the Baselayer system are:

- **Garment**. Full body construction (neck to wrist to ankle), sweat wicking, compressive, flame resistant or no melt/no drip, individually launderable.
- **Active Thermal Management System**. Compressor and micro-tubing for circulation of chilled/heated water to provide cooling or heating.
- **Physiological Status Monitoring and Displays.** Sense and display core and skin temperature, respiration rate, blood pressure, and heart rate.
- **Exoskeleton Control Sensing.** Electromyography (EMG) for predictive control of the exoskeleton.
- **Padding.** Friction protection and comfort.
- **Soft Armor.** Low speed fragmentation protection for non-vital organ regions (groin, arms, etc.).

4.5. Command, Control, Communications, Computing and Intelligence (C4I) – Computing Hardware and Software (CHW and CSW). The CHW and CSW are designed to enable situational awareness, voice and data communications, and temperature control of the Baselayer. Additionally, the CSW provides and open architecture that the computing environment is survivable, adaptable, and tailorable.

The CHW components include:

- C4I Backplane (computing processing nodes, solid state data storage, Global Positioning System (GPS) tether, network and data routing, Universal Serial Bus (USB) Hub, audio board)
- 2x Harris 7800 Radios (voice communication)
- MPU-5 Radio (data feeds)

The CSW includes the following high level software service groups:

- Command, Control, and Status services
- Operator Interface services
- Communications services
- Situational Awareness services
- Health Management services
- Power services
- Visual Augmentation System (VAS) and Helmet Control services

4.6. Helmet (HMT) and Operator Interface (OI). The HMT CM includes the ballistic shell and helmet padding but is managed by the Armor FA Lead. The Helmet functional lead manages and develops the VAS and the OI. The purpose of the VAS and OI capabilities are to improve situational awareness and target acquisition. The VAS and OI components are the following:

- **VAS**
    - Helmet Mount for VAS suite
    - Augmented Reality (AR) Heads-Up Display (HUD). AR Information includes geo-registered icons, friendly forces and threat locations, navigational waypoints, target location, breach points.
    - Electronic VAS bridge hardware for video processing, head tracking, display rendering, electrical control.

  - G-PNVGs with AR HUD overlay information.
  - VAS Cameras, thermal and Short-Wave Infrared sensors.
  - Lookdown microdisplays for ISR feeds, maps, status displays.
  - Assaulter Target Acquisition (CQB version of Army's RTA).
- **Helmet Accessories**
  - Ventilation system for de-fogging.
  - 3D Ambient Audio.
- **Operator Interface**
  - Chest Controller (2 Push-to-Talk (PTT), 7 buttons/Rotary Encoder, Touchpad, audio board, volume control, radio connections)
  - Forearm Controller (8 buttons, fingerprint reader)
  - Weapons Controller (wireless-Bluetooth, 4 buttons)

In order to achieve the TALOS objectives, the JATF has invested in a number of technical efforts to deliver a fully integrated MK 5 combat suit. Additionally, there are parallel efforts outside the MK 5 development. All TALOS technical efforts can be categorized by one of the following distinctions:

• **MK 5 Component Capability Delivery**: A stand-alone capability that is a component of the MK 5 system with an opportunity to transition.

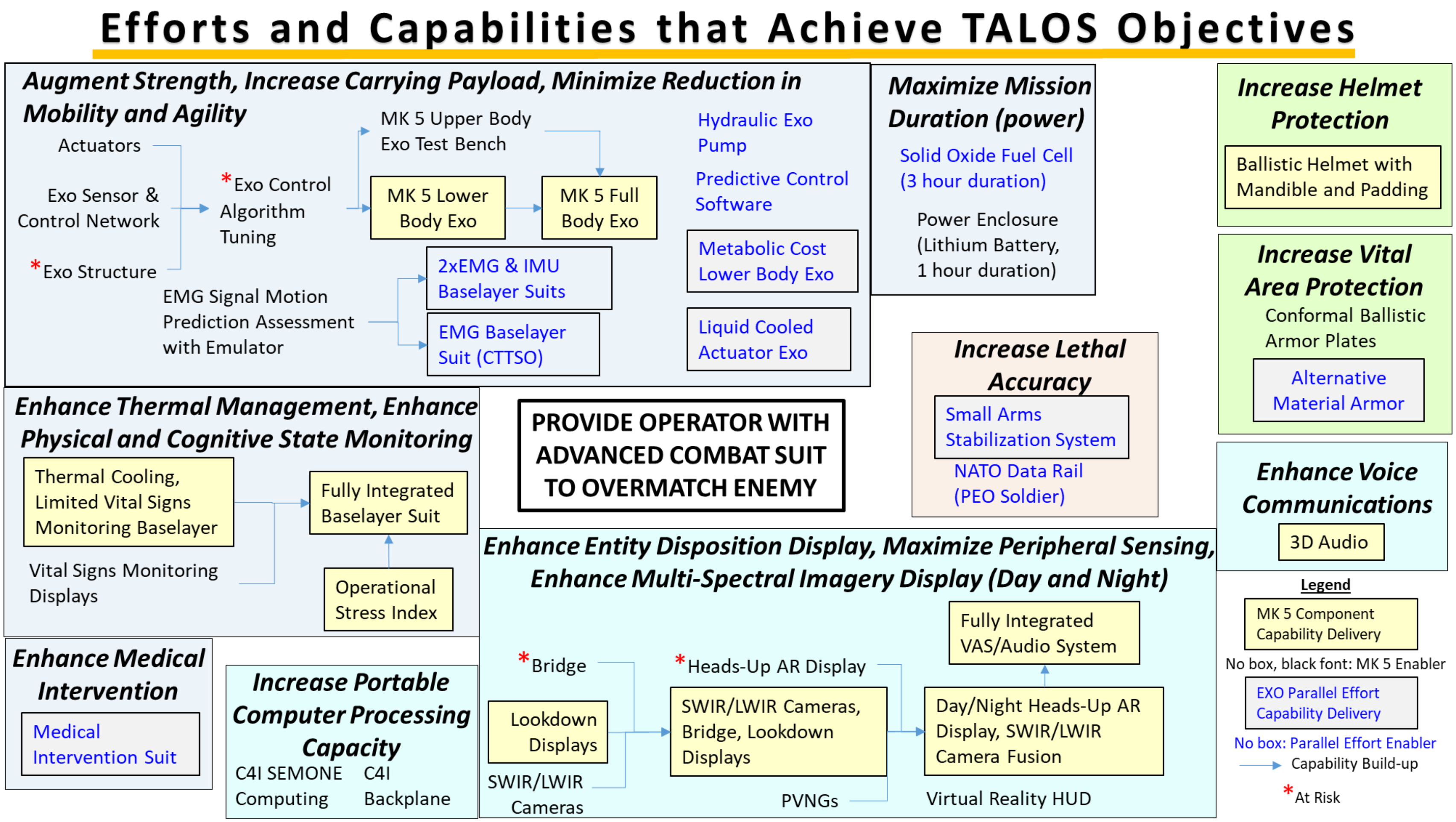
• **MK 5 Enabler**: A necessary component that enables the MK 5 integration and does not necessarily result in a stand-alone capability.

• Parallel Effort: Capability Delivery: A stand-alone capability not related to MK 5 with an opportunity to transition.

• Parallel Effort Enabler: A supporting capability not related to Mk 5 that needs further development prior to transition.

The figure below shows the efforts and capabilities that achieve the TALOS objectives.

5. Effort to Objective Mapping



6. Task Organization.

JATF TALOS is a matrixed organization with a collection of integrated project teams that are comprised of a mix (IPT) composed of operators, engineers, program managers, and vendors. The below table outlines each team, government lead, team members, team roles, responsibilities, and technical oversight efforts. The JATF team is a complex adaptive system consisting of self-driven, talented individuals capable of taking initiative to find necessary work without guidance. Outlining the team roles and responsibilities provides team members clear focus and the opportunity to find gap areas they can fill. The JATF fosters a learning environment to allow team members to gravitate towards roles and responsibilities they are passionate about and capable of accomplishing.

Team Name	Team Roles, Responsibilities, and Technical Oversight Efforts
TALOS Leadership	1. Provide administrative (ADMIN), business, technical, and programmatic leadership for the TALOS Project. 2. Gain customer trust/confidence in order to fully understand the requirement. 3. Measure and manage project performance and progress in an objective manner; forecast project performance problems and implement strategic decisions to optimize acquisition agility; capitalize on available and emerging advanced technology; efficiently, effectively and responsibly execute resourcing decisions. 4. Ensure the team understands a shared vision that will emerge by executing the SEP.
Engineering	1. Responsible for the test and integration plan and execution of the MK5 prototype development. 2. The decision authority for all engineering requirement, design, test, and integration decisions. 3. Implement teaming of FA Lead, Engineer, PM and operator. 4. Is overall responsible for the technical teams (System Engineering (SE) and FAs), SEP and Documentation. 5. Ensures that technical teams are cross-functional in design, purpose and effect; integrate Operators, PMs, Contracting Officer (KO) and when necessary Acquisition Lawyer. 6. Provides technical guidance/direction that is inclusive of Contracting Officer Representative (COR), and considers PM equities. 7. Reviews and approve functional area Technology Development Strategies/Plans. 8. Establishes and maintains Engineering processes. 9. Develop test and evaluation strategy. 10. Develop Modular Performance Specifications (MPS) and Interface Control Documents (ICD). 11. Manage the Integrated Master Schedule (IMS) (supported by FA leads). 12. Develop and manage the TALOS Integration Plan. 13. Define and implement review / approval processes for documenting the system design. 14. Define and coordinate trade studies and technical analysis in accordance with the FA Leads. 15. Develop and maintain Assembly Tree, and Test Assembly Tree models.

Team Name	Team Roles, Responsibilities, and Technical Oversight Efforts
	16. Safety is paramount during component and/or suit Human integration. Ensure that Risk assessments are prepared and submitted in a timely manner, approved for execution (with caveats) and reviewed in detail prior to any activity. Rehearse contingency actions and activities for medium and higher risk assessments. 17. Ensure that operators involved in and informed of TALOS current design and way ahead. 18. Maintain current and relevant technology gap/obstacles for outreach, innovative resolution methods (Prize Challenges) and future planning. 19. Review quad charts and white papers and provide recommendations to CHENG, PM, and Director for decision. 20. Support futures cell; integration of FA Lead, Engineer, PM and operator is paramount.
PM	1. Collaborate directly with Chief Engineer (CHENG) and FALs to define strategies and implement technology activities; author acquisition strategies, manage resources, lead IPTs, and present briefings in order to ensure timely awards, quality documents, and product lifecycle. 2. Collaborate directly with the contracting team in order to enable cost effective and efficient program execution. 3. Provide Technical oversight and coordinate with each COR for program efforts; serve as mentor and provide direct oversight to CORs. 4. Provide TALOS / SOF AT&L with more flexible and agile acquisition capabilities. 5. Enable high priority non-traditional acquisition/collaboration strategies to support the command. 6. Provide decision makers with more timely, accurate, and quality info in order to ensure sound decision-making processes. 7. Maintain, and where possible, improve execution rates; initiate new and more flexible acquisition processes. 8. Fulfill customer expectations and establish a strong working relationship with all levels of the organizations. 9. Develop TALOS budget strategy by leveraging Research, Development, Technology and Evaluation (RDT&E) funding from different programs (Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR)), RRTO, etc. and ensure execution with 10% of baseline. 10. Enable immediate support to unfunded priorities supporting the TALOS Program. 11. Develop and sustain the resourcing strategy roadmap. 12. Develop and sustain technology protection and classification management and adherence documentation, including information management policies and procedures.
CONTRACT	1. Lead for contracts to acquire TALOS needed supplies and services 2. Execute and maintain the integrity of the legal nature of contracts and the regulations that govern the contracting and procurement processes. 3. Coordinate with the agencies and contract personnel responsible for performing contracting functions. 4. Facilitate the pre-solicitation phase of contracting, enable and execute the soliciting, and award phase of contracting. 5. Perform the post-award phase of contracting including close-out.

Team Name	Team Roles, Responsibilities, and Technical Oversight Efforts
OPERATIONS	1. Primary responsibility for team sustainment support, including admin oversight, supply and services management and execution, SOF AT&L interface for tasking and interoperability, TALOS event orchestration and execution, Operator tactical/technical expertise integration and support to FA Leads, Vendors, Futures and SBIR/STTR. 2. Essential execution of TALOS manpower management, including requisitions, Physical Fitness, health welfare, accountability, performance reporting and awards. 3. Support Information Technology (IT) services for the TALOS team. Establish relations with the J6 to ensure the team's computer and internet connectivity requirements are sustained. 4. Submit IT Request for approval of IT equipment. 5. Manage the Government Purchasing Card (GPC) requests and purchases. 6. Manage and approve TDY/Leave. 7. Manage travel LOA's, authorize travel, and approve vouchers. 8. Serve as Test Operators ISO CHENG and PM 9. Serve as Subject Matter Experts for operational performance matters, current and future tactical applications, insights, verification and validation. 10. Serve as critical contact POC into units and for units into TALOS. Foster and sustain new relationships with SOF units as required. 11. Establish, foster and sustain professional relationships with PEOs and the respective PMs that influence TALOS technology transition options. Provide Operational SME support to PEOs as requested. Serve as SME for tactical units to the PEOs as requested and with unit concurrence.
Functional Area Leads (common to all)	1. Provides technical engineering expertise and guidance to the CHENG within the assigned FA. Maintains transparency and visibility of technical engineering input [provided to CHENG] to PM for situational awareness and PM oversight. 2. Provides Government technical direction to vendors under the COR's oversight. 3. Is overall responsible for the technical development of the assigned capability module within the respective integrated project team. 4. Develops the functional area Technology Development Strategies/Plans. 5. Executes the TALOS Engineering processes. 6. Develops and reviews the test assembly plans. 7. Develops Modular Performance Specifications and Interface Control Documents. 8. Manages the Functional Area portions of the Test and Integration Integrated Master Schedule. 9. Refines as needed the functional area requirements and captures lessons learned. 10. Reviews contract and Military Interdepartmental Purchase Request (MIPR) monthly reports and prepares for the monthly programmatic reviews. 11. Prepares for the periodic integrations reviews. 12. Plans and facilitates external vendor teleconferences. Post agendas and follow-on action items on Confluence

Team Name	Team Roles, Responsibilities, and Technical Oversight Efforts
	13. Ensures the TALOS Architecture developed using Systems Modeling Language (SysML) is updated with the appropriate hyperlinks to design information on Confluence. 14. Provides technical expertise for the failure and hazard analysis. 15. Develops and maintain Assembly Tree, and Test Assembly Tree models. 16. Reviews assigned white papers for technical viability and provides recommendations on whether to pursue the proposed technology. 17. Writes the technical reviews for vendor proposals. 18. Provide direct support to Futures lead and Operators when required to chart informed pathway decision making.
FUTURES, TRANSITIONS	1. Direct Future Ops: Engage with SOF AT&L-Science and Technology (ST), PEO, unit S&T, Technology & Industry Liaison Office (TILO), other services laboratories, academia, and industry on emerging technologies and develop stronger ties between the organizations to support tech insertion into, and out of the TALOS first article prototype. Research, identify, and leverage emerging technologies and capabilities being developed/utilized by commercial industry and United States Government (USG) program offices. 2. Connect with USSOCOM PEO to align the TALOS and PEO Roadmaps. Establish process, tools and mechanism to communicate and analyze potential tech transition in and out of TALOS. Priority to USSOCOM PEO in support of User units, then service and agency entities. 3. Identify opportunities to address S&T roadmap gaps, deliver improved/enhanced capabilities, and manage/reduce risk. 4. Identify, record, and manage the TALOS technological gaps. 5. Visualize and describe future TALOS capabilities organic to future combat suit evolutions, characteristics and other contemplated capability use cases. 6. Maintain the TALOS Advanced Turn-Table and future development of our strategic messaging web interface. 7. Liaison with Component and Unit CDDs/S&T / 8's to transition technologies and receive their feedback on TALOS efforts. Ensure that Operators establish relationship with respective service/unit to facilitate information exchange, capability and project awareness including prioritized interests or demands. 8. Conduct timely industry business outreach, market research and development to identify options for tech gap resolution. 9. Continuously update/leverage TALOS and SOF AT&L portals to communicate program info. 10. Develop and sustain the TALOS marketing strategy. Lead TALOS marketing to effectively communicate TALOS vision, status, capabilities, tech gaps, transition able capabilities. 11. Gain customer trust/confidence in order to fully understand the requirement. 12. Develop and sustain the Exoskeleton variant roadmap. 13. Develop and sustain the combat suit prototype roadmap. 14. Develop and sustain the tech transition roadmap. 15. Develop and sustain the OPSEC roadmap.

Team Name	Team Roles, Responsibilities, and Technical Oversight Efforts
TEST and SAFETY	1. Manage the test and integration process in coordination with the Vendors and FA Leads to ensure that the appropriate testing is done to ensure the safe operation of all parts of the program. 2. Ensure that all vendors are delivering required test results and reports prior to the integration into the TALOS Assemblies. 3. Ensure that all safety and security processes are in place prior to operator use and integration with other FAs. Ensure the Mishap Risk Assessments are complete with enough time for the approval process needed to prevent schedule blocking. 4. Coordinate with the USSOCOM Safety Officer to ensure all necessary preparations are complete to perform human testing. 5. Provide oversight on external organizations involved with failure and hazard identifications and safety assessments. 6. Perform Failure mode, effects, and criticality, hazard, and fault tree analysis for all functional areas. 7. Leverage the MBSE Test Framework to manage the Master Test Plan. 8. Assist the MBSE team to derive the test assembly block, internal block, use case, activity, sequence, state machine, and requirements diagrams as needed.
INTEGRATION	1. Manage the Integrated Master Schedule Baseline (both Test and Integrations IMS and the EXO IMS). Refine task definitions and schedule structure as needed. Collect and integrate task duration and precedence changes from functional IPTs. Re-baseline the IMS as needed. 2. Perform critical path analysis in order to understand risk implications to schedule that are a result of Baseline variation. 3. Prepare schedule reports to communicate project status from multiple perspectives (TALOS, functional areas, test and integration, risk mitigation plans, burn down charts). 4. Manage the issue, risk, opportunity, hazard, action item, and decision registries. 5. Manage the Confluence document repository and MBSE Systems Integrated Model developed in SysML that will comprise the technical data package for the TALOS system. 6. Manage the MagicDraw exported tables as described in the TALOS Modeling and Data Management Architecture section. 7. Manage the Computer Aided Design (CAD) files in Confluence and when able, develop a fully integrated CAD model of the complete TALOS system. 8. Prepares for integration audit reviews and engineering synchronization agendas.
Requirements Management	1. Refine, as needed, the System and Capability Modular level requirements and all other supporting documentation required therein by TALOS or the Chief Engineer. As necessary, adjust structure and add more derived requirements down to specification level when able. Ensure Requirements are necessary, implementation free, unambiguous, consistent, complete, singular, feasible, traceable, and verifiable. 2. Manage Traceability to structural elements and Concept of Operation (CONOP) Tasks. 3. Assist with the development and execution of system and subsystem test plans to aid in the measurement of Technology Readiness Levels (TRL) in a programmatic milestone or deliverable. 4. Translate requirements into the functional performance statements that will inform the test contexts for each test assembly (see the MBSE Test Framework section).

Team Name	Team Roles, Responsibilities, and Technical Oversight Efforts
	5. Refine the requirements as TALOS learns more during the integration phase in order to arrive at a legitimate set of requirements that will inform future TALOS system variants.
MBSE	1. Refine and maintain the TALOS Baseline SysML model. Establish the modeling conventions used by the MBSE team to ensure consistent definitions and instantiations of structural and behavioral features of the TALOS system. 2. Execute MagicDraw scripts as needed to facilitate data import and export of the TALOS Baseline SysML model. 3. Support the traceability of the structure, behavior, and requirements within the MagicDraw tool. 4. As needed, define (in SysML) use cases, activities, state machines, interactions/ sequences, and use cases. 5. Auto-generate Module Performance Documents (MPRs), Interface Control Documents (ICDs), and RVTMs. 6. Produce and maintain a map of delivery configuration items (CI) to integration and functional uses. 7. Maintain a list of assemblies made specifically for analysis and support, and link to CIs required to assemble subsystems and systems. 8. Capture individual interfaces and connections to support the burn-down of interface definition and validation work. 9. Auto-generate burn-down lists and status as needed for interfaces, requirements to verify, and other items as needed. 10. Provide an "authoritative source" of information such that when two depictions of the system conflict, a determination of the current version can quickly be made. 11. Provide direct references between system element, status (e.g., baseline), and authority (if baseline or revision to baseline). 12. Establish a model release cadence that provides some stability while remaining responsive to change (e.g., once a month). 13. Release technical data updates as deltas against baseline configurations rather than "data dumps" without context. 14. Support systems engineering processes with reports on set of items that may need additional engineering analysis as result of given changes. 15. As needed, post-process data from analyses, inspections, demonstrations, and models to facilitate ingestion into the MagicDraw tool. 16. Perform requirement change impact analysis. 17. Monitor logical interfaces through systems engineering and analysis. 18. Capture configurations including key support equipment. 19. Capture modifications to hardware and software to provide situational awareness to other functional areas. 20. Drive a clear definition of observables to be assessed that support requirements verification. 21. Provide a lightweight functional allocation to assure coverage of CONOP-supporting functions during program execution. 22. Track safety-critical items and configurations and use the model to check for changes that may break safety-approved configurations.

7. Program Management Oversight Assignments.

The JATF manages a number of different types of programmatic efforts. The following tables define the types of efforts and the positions the JATF assigns to individuals that will manage the oversight of these efforts.

Effort Type	Definition
Contract	A formal binding legal agreement between two parties for the purchase of goods or services.
Contract (Pending)	An internal or external contract effort that has not yet been awarded, but for which a decision has been made to fund and there are active efforts in pursuit of contract award.
Contract (SBIR)	A Small Business Innovation Research or Small Business Technology Transfer are efforts that fit specific criteria and depart from the normal Government format and requirements for contracts in order to simplify the contract award process and minimize the regulatory burden on small businesses.
External Contract	Goods or services purchased by passing funds to a contract vehicle outside of TALOS. There is an external COR assigned, but a TALOS COR Representative performs TALOS-specific duties in liaison with the formally-assigned COR.
MIPR	Military Interdepartmental Purchase Request. A CFR-designated method to transfer funds amongst U.S. military organizations to pay for goods or services, without having to use a formal contract. No COR is assigned, but the TPOC does work to coordinate the SOW/SOO, line up the funding and track the implementation of the agreement.
Oversight	An effort that is administered by an external contract and where TALOS pays nothing or only a portion of the bill, but provides management, liaison and technical advice towards transition opportunities for the technology.

Position Type	Definition
COR	A Contracting Officer Representative (COR) is formally designated in writing to provide technical direction, clarification and guidance with respect to the contract specifications and SOW. The COR acts as the technical liaison between the contractor and the Contracting Officer and duties include verifying acceptable contract performance, tracking expenditures, accepting deliverables and approving invoices. For MIPRs, if a COR is listed, the MIPR is to another agency that has a contract with the vendor or the COR listed is the main POC.
TPOC	The Technical Point of Contact is a designee who is well-versed in the contract history, objectives, and current status. Typically, the TPOC can assist the COR with provision of technical direction to the vendor, answer technical questions, perform the proposal technical evaluation, and act as a SME on the contract's progress.
TALOS COR REP	For external contracts or other efforts whose formal management and administration falls outside of TALOS, a TALOS COR Representative acts as the TALOS external POC to the formally-designated COR, performs COR-like duties, and generally acts as an advocate for TALOS to that contract effort.
MIPR POC	For MIPRs, the TALOS POC is responsible for writing the SOW/SOO, tracking transmit and acceptance of the MIPR and dealing with any other administrative issues that pertain.

8. TALOS Battle Rhythm.

The JATF conducts various external and internal meeting throughout the week. The section outlines the types of meetings, their purposes, and scheduled periodicity.

8.1. TALOS Team Synchronization.

The purpose of the TALOS Team Synch is to review administration, travel projections, Distinguished Visitor schedules, routine operations, and provide a venue to communicate Integrated Project Team statuses.

8.2. TALOS Stand-ups.

The purpose of the TALOS stand-ups are to check everyone's priority of work and limit the time to 10 minutes only (twice a week). The intent is to highlight to the larger team critical information as needed and will be conducted in the TALOS "Pit" work area.

8.3. Engineering Synchronization.

The purpose of the Engineering Synch is to review the status of integration level events, spot check CI and Test Assembly statuses, conduct in-depth integration schedule reviews, JIRA tickets, and various other engineering related actions as needed. Each meeting will focus on various reviews as described in the Integration Audit Review Section of the SEP.

8.4. Programmatic Reviews.

The purpose of the Programmatic Reviews is to focus on vendor level cost, schedule, and performance risks, issues, and opportunities (transitions). Technical Point-of-Contacts (POC) and CORs will prepare for the reviews by extracting relevant information out of the vendor monthly reports and report vendor statuses to the larger team. Intent is to facilitate a discussion that measures and manages project or effort performance in an objective manner, and provides the ability to forecast project performance problems/risk.

8.5. Integration Work Sessions.

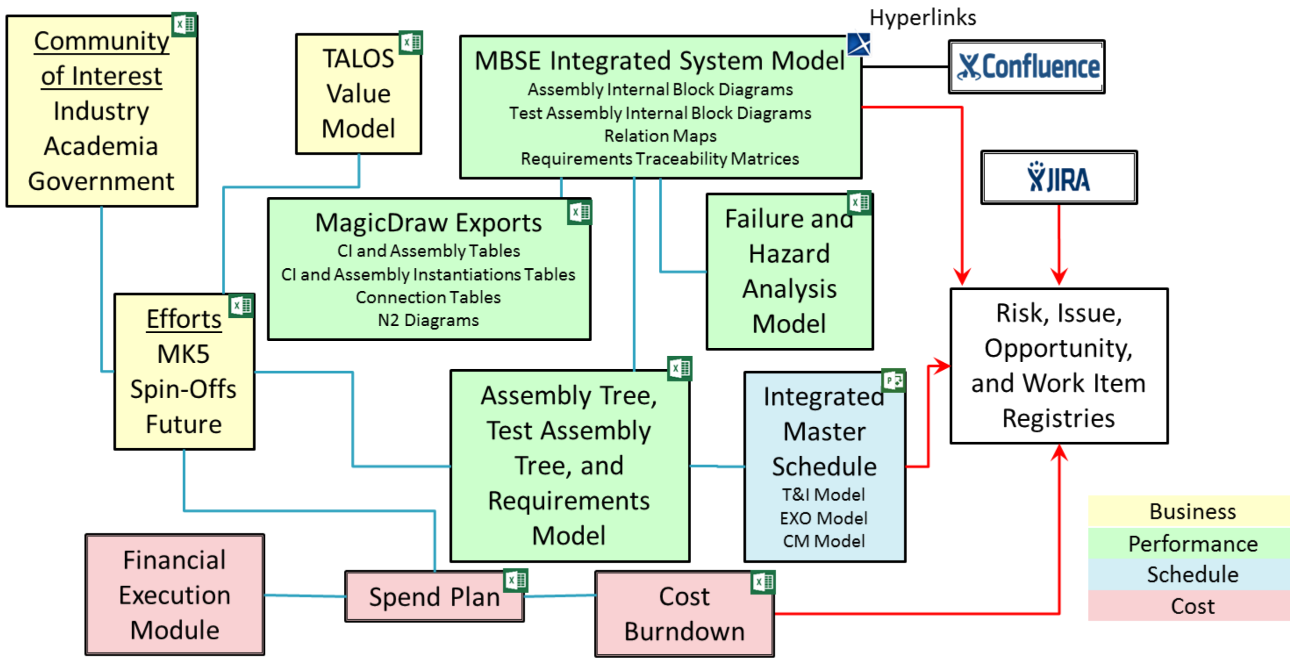
The purpose of the Integration Work Sessions is to conduct collaborative team work on various topics as needed. These topics include, functional area and assembly/ test assembly deep dives that baseline the Integration Audit Reviews, failure and hazard analysis workshops, schedule reviews/refinements, and other topics that require a lengthy work session. These sessions will only be scheduled as needed.

8.6. External Vendor Teleconferences.

The purposes of the external vendor teleconferences is to collaborate with our vendors to provide government direction, review vendor statuses, and to serve as the integration meeting between vendors.

9. TALOS Modeling and Data Management Architecture.

In order to facilitate a shared understanding among the TALOS team, the JATF will use a collection of related models to manage the technical development of the MK5 and other efforts from a business, cost, performance, and scheduling perspective. Each model will have a key value identifier that relates elements to other elements of the other models as depicted by the blue lines in the below figure. Element types include partners within the community of interest, TALOS objectives within the Value Model, spend plan events, scheduling tasks within the Integrated Master Schedules, structural and behavioral elements within the MBSE SysML Model. The red arrows in the below figure indicate the data flow from the cost, schedule and performance models that inform the management of risk, issues, opportunities, and work item registries (see the Engineering Management Processes section for the definitions of these registries).



Each model type is classified as either a business, performance, schedule, or cost model. The following subsections describes the purpose of each of these models.

9.1. Business Models.

9.1.1. **Community of Interest**. A table that records the collection of organizations and stakeholders within industry, academia, and government involved with the TALOS Project. The purpose of the model is to support TALOS stakeholder management planning and strategic up and out messaging of our collaboration efforts. The model will contain the following fields within the Excel file:

- Organization
- Type: Industry or Academia or Government
- Description of Support
- Points of Contacts
- Technical Efforts involved with: MK5 Capability Module or Transitions or Futures
- Type of Support: Contract or MIPR or Cooperative Research and Development Agreement (CRADA) or Partnership
- Longitude and Latitude of organization location (used to display organizations on a map)

9.1.2. **Technical Efforts**. A table that records descriptions of the TALOS technical efforts that are parallel paths and future roadmap initiatives. The efforts include the MK5 prototype delivery within each capability module, spin-off transition opportunities, MK6 and other future initiatives, parallel Exoskeleton designs.

9.1.3. **TALOS Value Model**. A decision analysis model that uses the philosophy of Value-Focused Thinking to model an exhaustive characterization of every aspect of the TALOS vision and defines the TALOS leadership preference structure. The purpose of the model is to define the fundamental objectives that serves as the basis for all design, integration, and funding decisions.

9.2. Performance Models.

9.2.1. **Assembly Tree Model**. The purpose of the Assembly Tree Model is to capture the TALOS configuration items (CIs) and assign them to the appropriate assembly. The model is a hierarchy that is decomposed from the Full TALOS System down to the lowest level CI. The assembly tree model conveys the part decomposition of blocks and is the basis of our block definition diagrams; they do not convey connections between blocks. Each assembly and CI will be defined as an element of definition in SysML (typically a block but can also be an interaction, activity, or state machine). The connections between blocks are conveyed using an Internal Block Definition Diagrams (IBDs). The Assembly Tree Model will initially serve as an input to the development of the MBSE Integrated Systems Model. Once the system model is baselined, control of the Assembly Tree model will be managed in MagicDraw; a generic table export will then update the Excel version of the Assembly Tree.

9.2.2. **Test Assembly Tree Model**. The purpose of the Test Assembly Tree Model is to capture the test and integration activities we intend to perform. The hierarchical structure conveys a logical build up into higher level test assemblies and the part whole structure of the Master Test Plan. The test assembly hierarchy is represented as a block definition diagram within our integrated system model; each block will equate to a test article within our TALOS MBSE Test Framework. The Test Assembly Tree model is the basis for our Test and Integration Schedule. Internal Bock Diagrams will convey element connections within the test assemblies.

9.2.3. **Requirements Model**. A tabular Excel database that contains the System Requirements and Modular Performance Requirements. The purpose of the model is to include additional fields of information that facilitate requirements analysis. Each requirement has an identifier. Requirements will be in a continual state of development as we characterize the TALOS system. Because of the unprecedented nature of the system development many of our requirements will be derived throughout the design, test, and integration phases. The Requirements model will allow for the continued maturity of their specification.

9.2.4. **Failure and Hazard Analysis Model**: Refer to the Hazard Management Process.

9.2.5. **MBSE Integrated System Model**. The purpose of the system model is to represent the architecture of the TALOS system and contain the ground truth configuration information. The model will serve as the database of all requirements, CIs, assemblies, test configurations, and interfaces within the TALOS system. The system model along with the design specification documents within Confluence will constitute the Technical Data Package of the TALOS system. The model uses the Systems Modeling Language (SysML) to graphically display and trace the connections between discrete elements. The following sub-sections describe the collection of products produced by MagicDraw that will assist the TALOS team with understanding the TALOS system complexity.

9.2.5.1. **Assembly IBDs**. A visual model that specifies the internal structure of an assembly that reveal types of connections. The purpose of the Assembly IBD is to convey how the parts of the assembly must be assembled to create a valid instance of the assembly.

9.2.5.2. **Test Assembly IBDs**. A visual model that specifies the internal structure of a test assembly that includes the test resources needed to perform the test. The purpose of the test assembly IBD is to convey how the CIs involved in the test are connected together along with the test resources (fixtures, emulators, test benches, etc…).

9.2.5.3. **Relation Maps**. Relation maps are hierarchical images created by MagicDraw showing the decomposition of the assembly tree, the test assembly tree, and the requirements tree.

9.2.5.4. **Requirement Traceability Matrices.** These matrices show the requirements traceability to selected system elements using the following relationship types: trace, allocate, satisfy, and verify.

9.2.6. **MagicDraw Exports.** The following are generic tables created by MagicDraw and exported into Excel for wider consumption throughout the TALOS team. The structural blocks will use stereotypes and value properties to capture feature information.

9.2.6.1. **Configuration Item and Assembly Table**. An Excel table exported from MagicDraw that lists all CIs and assemblies. This list should be the block type only (not every instance of the CI). The purpose of this model is to track the CIs and assemblies as single units that will have their own design specifications and interface control documents. The table will have the following fields:

- Identifier
- Type Name
- Classifier: CI or Assembly or Test Assembly or Test Resource
- Assembly Tier Level
- Capability Module (EXO split into EXO Actuation, EXO Sensors, EXO Controls, EXO Wiring, EXO Structure, BSL, HMT, ARM, CHW, CSW, VAS, PWR)
- When applicable, vendor delivering the CI
- Weight (lbs) as a value property
- When applicable, relevant specification parameters as a value property
- Design Status: None or Draft or Preliminary or Baselined or Detailed Design Complete
- Confluence hyperlink to design specifications

9.2.6.2. **Configuration Item and Assembly Instantiations Table.** The same table as the Configuration and Assembly Table only this one lists every instantiation of all block types. The purpose of this model is to capture the entire list of CIs and assemblies to convey the total quantity of elements and roll up mass calculations. Table fields in addition to the ones already mentioned above include:

- Instance Name
- Connection Type: Logical or Electrical or Physical

9.2.6.3. **Connection Table**. A table that describes each connection within an Internal Block Diagram for either an assembly or a test assembly. The purpose of the table is to allow for comment resolution and to capture information about how elements are connected. The tables fields include:

- Connection Name
- Hardware A
- Hardware A Connector
- Flow over Connector A
- Connects to this Hardware B
- Via this Hardware Interface

- Flow over Connector B
- Identifier
- Assembly Tier Level
- Type Name
- Classifier: Physical or Logical or Electrical
- Capability Module (EXO split into EXO Actuation, EXO Sensors, EXO Controls, EXO Wiring, EXO Structure)
- When applicable, vendor delivering the CI
- When applicable, weight (lbs) as a value property
- When applicable, relevant specification parameters as a value property
- Design Status: None or Draft or Preliminary or Final
- Confluence hyperlink to design specifications

9.2.6.4. **N2 Diagrams**. A matrix representing physical, logical, and or electrical interfaces between system elements. TALOS primarily will use structural elements along the diagonal to form coupling matrices. Within the matrix, interface outputs are depicted in the upper left triangle and the inputs are depicted in the lower left triangle. The coupling matrices allow for optimizing the aggregate assembly definitions and verification of interfaces. Reorganizing the coupling matrix to form compact aggregates could inform the TALOS integration strategy by minimizing the interfaces to be verified and inform the sequence buildup of the assembly tree.

9.3. Schedule Models. TALOS maintains two schedule models developed in Microsoft Project that comprise the Integrated Master Schedule. Each model contains the task definitions, duration, and precedence structure for the work needed to deliver the MK5 prototype. The purpose of the schedule models is to analyze the critical path, manage deviations from baselined schedule, and prioritize tasks. The models have interdependent tasks that are managed in accordance with the schedule management plan. The models that comprise the IMS include:

9.3.1. **Test and Integration (T&I) Schedule.** The T&I schedule itself consists of a conglomeration of two schedules: the detailed vendor tasks necessary for delivery of each CI and the overall test and integration schedule that builds from lower-level to higher-level assemblies. The model is structured such that a summary task within Microsoft Project is an assembly. Each sub-task within the summary task includes the design, development, vendor test, verification, and inspection of CIs and assemblies needed prior to performing the assembly integration at the TALOS level. The last sub-task in the summary task represents the task duration planned for executing the assembly test. The summary task for the assembly is complete when all of its component CIs and assemblies are ready for integration and the assembly if verified and ready for higher-level integration. The test and integration tasks cover the events managed by the TALOS program to enable building up the suit components into higher level assemblies. The Exoskeleton CM has a separate schedule due to its complexity and scope; however, although Exoskeleton tasks are not explicitly covered, there are interdependencies that are mapped directly from the Exo schedule to support TALOS test and integration tasks.

9.3.2. **Exoskeleton Development Schedule**. The Exoskeleton development is the critical path of the TALOS system maturity. The development paths for the structure, the actuators, and sensor and control hardware and software areas are unique, complex, and highly coupled with several interdependencies that require a separate schedule model.

9.4. **Cost Models.** Cost Management is led by the TALOS Program Manager.

9.4.1. **Spend Plan.** The purpose of the spend plan is for the PM to record projected spend allocations toward the technical efforts that the JATF is pursuing currently and intends to pursue in the future. The fields within the spend plan model allow for the TALOS leadership to visualize spend plan allocations using tables and charts. The following are the spend plan model fields:

- For each Fiscal Year (FY), the amount allocated to a spend plan event, the obligation data, and the unfunded amount
- Other People's Money (OPM) amount
- Area: HMT or VAS or PWR or BSL or CHW or CSW or EXO or OI or SE or SME or TEST
- Fund Type: Active Contract or Admin or External or MIPR or Not Funded or Pending Contract or SBIR/STTR
- System: Mobility or Tactical
- Effort: Admin or Futures or MK5 or Parallel EXO or SME or Transition
- Funding Line: O&M or RDT&E
- EOC: External or O&M or SBIR/STTR or SOST or SOTD
- Event Type: Baselayer RDT&E or Body Armor RDT&E or C4I RDT&E or Exoskeleton RDT&E or Helmet RDT&E or Power RDT&E or SE & Program SPT O&M or SE & Program SPT RDT&E

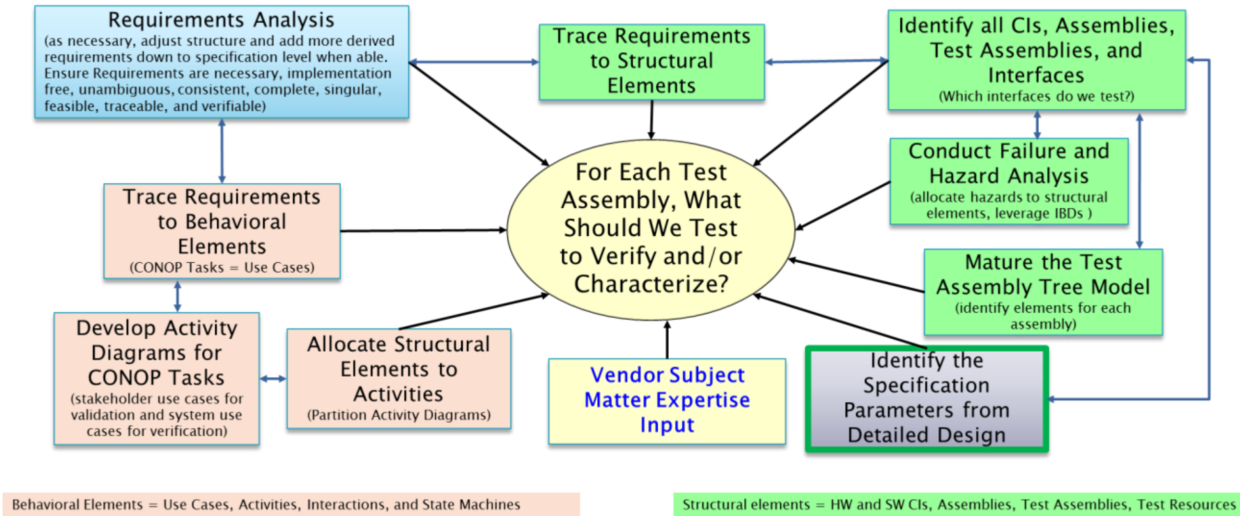
9.4.2. **Financial Execution Management (FEM) Export Model.** The FEM database is a web-based data management system used to track financial allotments and expenditures. Data exports allow the TALOS team to conduct bi-weekly financial reviews with the TALOS Leadership. Historical data exports allow the TALOS team to perform cost analysis on our expenditures in order to help inform lesson learned and future development cost estimations of our technologies. The purpose of the FEM Export Model is analysis of the historical spending patterns throughout the TALOS Project lifecycle. The model is a macro-enabled Excel file with Visual Basic for Applications (VBA) algorithms that organize and filter TALOS related FEM data into a form to allow for analysis.

9.4.3. **Cost Burndown Model.** The cost burndown model tracks the financial expenditures of each contract/MIPR using data from the vendor monthly reports. The purpose of the model is to visualize the burn rates of vendors with a graph in order to identify if and when a vendor runs out or has excess funding earlier than scheduled.

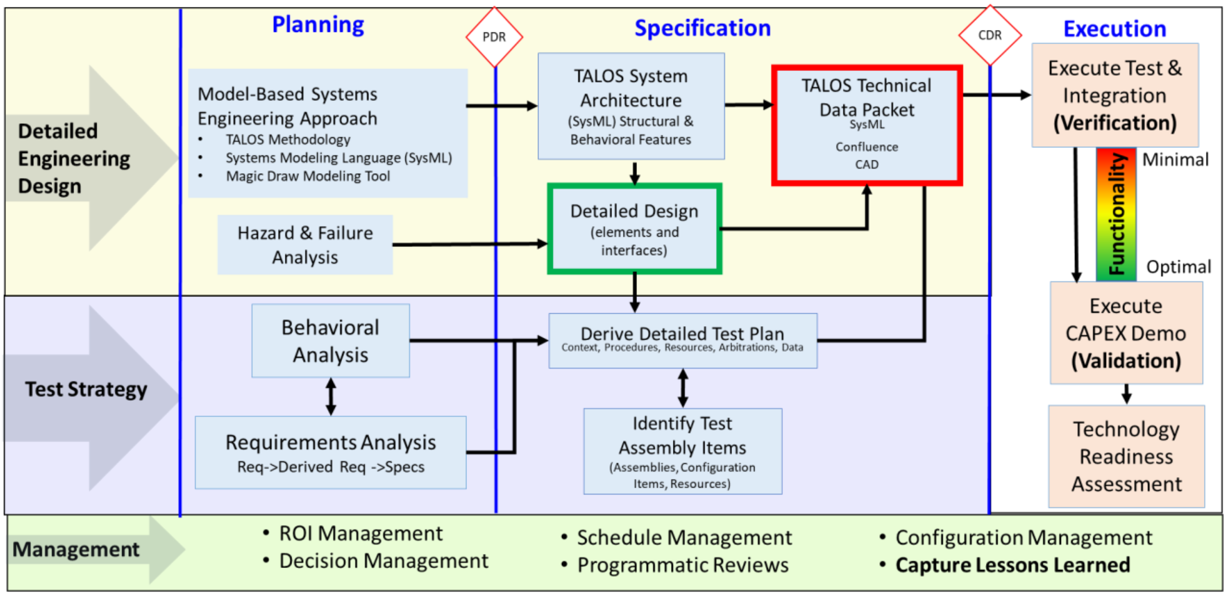
10. Test, Verification, Integration, and Validation Plan.

System verification is a set of tests used to check the correctness of the TALOS structural elements. Traditional system verification involves the confirmation, through the provision of objective evidence, that specified requirements have been fulfilled. Due to the nature of the TALOS Project rapid development environment, the TALOS system and modular performance requirements will evolve throughout the design, test, and integration phases of the project. Because TALOS is an unprecedented system with a limited project completion timeframe, thus traditional system engineering verification processes must be tailored to meet the complex and uncertain development environment of the TALOS Project. The verification plan must at a minimum ensure the safety of the operator and secondly verify that the system functions properly as designed. The following sub-sections describe the planning activities that support the test case derivations and the Test and Integration Execution Plan.

10.1. **Test Verification Planning Activities.** The figure below shows the collection of activities that support the test case derivations for each of the test assemblies. Traditional systems engineering generally flows through the activities shown in the below figure in a clockwise fashion (starting from the bottom left). Due to the rapidly evolving state of the system and uncertain development environment, the JATF conducts these activities in parallel.



10.2. **Test and Integration Execution Plan.** Because of the varied level of design development within each of the capability modules, preliminary and detailed design as well as the test planning and execution evolve simultaneously. The test and integration execution plan has three phases, planning, specification, and execution. The figure below shows the activities and modeling efforts within each phase. The figure shows three lines of effort that align with the detailed engineering design development, the Master Test Plan execution, and the Engineering Processes used to manage the TALOS Project (see the TALOS Engineering Management Processes section). Despite each vendors varied development schedule, the TALOS leadership is responsible for the technical reviews and audits of the TALOS system. The milestones shown in the below figure show where the TALOS preliminary design review (PDR) and critical design review (CDR) will occur before the execution of the system verification and validation. The TALOS PDR and CDR will not be completed at one discrete time. The components of each test assembly will evolve continuously such that different test assemblies will be in different phases of the test and integration execution plan.



The following sub-sections outline the planning, specification and execution phases of the Test and Integration Execution Plan.

10.2.1. **Planning.** Prior to the TALOs PDR, all TALOS models and artifacts will be baselined. The MBSE Integration Model will provide a database of all CIs and their interfaces (both internal and external) and a full representation of the TALOS architecture, to include the test assembly decompositions. Additionally, the failure and hazards have been identified with mitigations.

10.2.2. **Specification.** Prior to the TALOS CDR, the detailed design of test assembly CIs and their interfaces are complete as well as the test framework derivations. TALOS will produce a Technical Data Packet that will include the MBSE integrated models with hyperlinks to Confluence where the detailed design specification documents will reside.

10.2.3. **Execution.** Each test assembly will be verified in accordance with the derived test framework for that test assembly. The specifics for each test assembly will be defined within the MBSE test framework (see the MBSE Test Framework section). Each test plan will include courses of actions (COAs) for if and when tests fail. These COAs will include fault detection plans and debugging procedures. Prior to any human testing, a Mishap Risk Assessment must be approved. The Capability Exercise (CAPEX) will serve as the validation exercise for the TALOS system. Prior to the CAPEX the operator wearing the TALOS system will be fully tested in a lab environment.

11. Integration Audit Reviews.

JATF TALOS will conduct periodic integration reviews for each functional area and or high-level assemblies in order to audit the design, tests and integration of the TALOS system. The frequency of the review will be dictated by the TALOS leadership based on the maturity of each functional area and high-level assembly status. The integration reviews are subdivided into several types of lower level reviews. Each functional integration review will update the TALOS team with the maturity of each of these lower level reviews. Due to the nature of the TALOS system development, the maturity of each lower level review will evolve at a different rate. The following sub-sections describe each of these review types.

11.1. Design and Integration Review.

The purpose of the Design Review is to understand maturity of the CIs, assemblies and their internal and external interfaces within the TALOS system architecture. The CI and Assembly Table, the Internal Block Diagrams, and Connection Table exported from MagicDraw as well as information from confluence will contain the data used to build the review presentation in PowerPoint. Included in the presentation will be pictures and or CAD drawing of the CIs and Assemblies. The focus of the reviews will be to check the status of each CI, their interfaces, and identify issues with resolution plans to address them. The Tables will serve as a status check on the Design Status of each CI, assembly and their interfaces. Interface reviews will be partitioned into internal and external logical, electrical, and physical interfaces. The table below defines the design status categories and their criteria.

Design Status	CI, Assembly, Internal and External Interface Status Criteria
TBD	• To be determined CI that will be as built once identified. Does not need design development
As-Built	• CI is available as is and does not need any detailed design development. • Commercial-Off-the-Self
Draft	• CI, assembly, or interface is identified, represented in the MBSE Integrated Model but has not satisfied the Preliminary Design Status criteria.
Preliminary	• CI and interface connection stereotypes, value properties, and parts are fully defined (See CI and Assembly Table and connection Table field lists). • CI interfaces, external, and internal assembly interfaces have been documented in an interface control document and reviewed by stakeholders. • Vendor test verifications that need TALOS observations are identified. • Functionality has been agreed to and implementation approach is generally understood; functional requirements are enumerated and general technical approach is provided.
Detailed Design complete	• Generated environments and environmental susceptibility are well-understood, known not to be a concern from previous experience, or identified as items to be examined under test. • The detailed design of the CI satisfies the external and internal interface requirements specified in the ICD. • If detailed description of ICD satisfaction is not given, an appropriate Integration Event has been identified to resolve remaining issues. • Relevant CASS documents have been developed and reviewed by stakeholders. • Functionality is assigned to specific components working alone or in concert within the design. • The CI detailed design forms a satisfactory basis for proceeding into fabrication, integration and testing. • Manufacturing processes identified with their capability to meet design tolerances specified.
Inspection Complete	• The CI or assembly has been tested and verified by the vendor, inspected by TALOS, and ready for integration into the appropriate assembly. • The CI meets budget requirements (mass, power, throughput, time to doff / don, etc.) • CASS messages are produced and consumed according to documentation.

11.2. Requirements Review.

The purpose of the Requirements Review is to check the status of the requirements model as TALOS continues to mature them during the test and integration of the system development. Requirements will be reviewed by functional area to assess whether they are necessary, implementation free, unambiguous, consistent, complete, singular, feasible, traceable, and verifiable. Systems requirements should be traced down to modular performance requirements (functional area) that are further traced down to a specification level where able. Decomposing requirements will be on ongoing endeavor as the JATF tests and integrates the TALOS system. The intent is to refine the requirements as needed so that by the end of the TALOS CAPEX demonstration we will have quality requirements that will direct future implementations of another TALOS variant. Prior to the review, the requirements that need modifications will be classified using the statuses shown in the table below.

Change Status	Description
Allocate	Requirement needs to be derived and traced down to a lower level (SRD to MPR to Assembly to CI to specification level)
Update	Requirement needs updated due to the changing environment to ensure they are correct
Define	Requirement needs further definition to eliminate ambiguity.

Each requirement will be classified according to the categories in the below Table. These categories will assist with the derivation of the tests the JATF will perform to verify the requirements and ensure the operator’s safety.

Category	Category Description
Composition	Requires that a given component is in the system, material, or design rule is used (e.g., "There shall be a network switch in C4I.")
Doff/Don	Related to requirements on putting on or taking off the suit within a given time
Environmental	Specifies TALOS operational environment/requirements (e.g., operate in humidity, don't produce too much acoustic noise)
Functional	Specifies functionality of part of TALOS ("C4I shall provide data connectivity between CM's")
ICD / CASS	A requirement that specifies physical, logical, electrical, or data interface between components
Logistics	Specifies features of TALOS to support logistics ("Must ship within CONUS," "provide unfettered access to load points")
Motion and Comfort	Requirements that TALOS not overly restrict motion or provide discomfort
Performance	How well functions are performed
Quality	Specifies "-ilities" that provide impression of quality - availability, ease of maintenance, long time between failures
Safety	Specifies safety features or standards for TALOS
Technical Resources	Constrains mass, power, data, etc.
TRL	Requires that components reach a given technical maturity (on the DoD TRL scale)

Each requirement will be designated as a threshold (minimal level of desired achievement), an objective (intend to meet but not required), and ideal (beyond achievable for the MK5 but desired in future variants). The requirements model will designate the verification techniques that will be used to verify each requirement (see the MBSE Test Framework section for the verification technique descriptions).

The requirements model will also allow for the allocation of requirements to CIs and assemblies. These allocations will be captured within the MBSE Integrated model. The requirements classified with a functional category informs the functions the system intends to perform. As part of the requirements review, the JATF TALOS will assess the ability of the designed CI and assemblies to perform these functions.

11.3. Failure and Hazard Review.

Prior to the review, each functional area will prepare an update to the work that is completed within the Failure and Hazard Analysis model. During the review, a status check will be made to understand what work is left to be complete and update progress on the failure and hazard mitigations plans.

11.4. Interface / CASS Review

The purpose of the Interface / CASS review is to check that both sides of a hardware or messaging interface understand what they should provide and expect to be provided to them. If standard or off-the-shelf interfaces (e.g., Ethernet, protobuf) are to be used, then relevant configuration parameters should be in agreement. Custom interfaces should be described to sufficient detail that implementation risk is low.

If interfaces are only between two Functional Area leads and the complexity is sufficiently low, this review can be waived if joint working sessions are scheduled to co-develop components that have mutual dependencies. The interface description can then be captured as-built.

11.5. Test Assembly Readiness and Verification Review.

The purpose of the Test Assembly Readiness and Verification Review is to check the status of the test derivation, planning, test article readiness, and outcome of the tests for each of the test assemblies represented in the Test Assembly Tree model. The scope of the review is to focus only on the test assemblies TALOS is primarily responsible for to ensure the safety of the operator and the system performs the intended system functions. The modeling artifacts used to review test assemblies are the Test Assembly IBDs, the Test Framework Instance Table, requirements diagrams and requirement traceability matrices. The table below outlines the maturity status criteria for each test.

Status	Test Assembly Status Criteria
Identified	• Test Assembly objective is specified and represented in the MBSE Integrated Model.
Test IBD Complete	• CIs and interfaces within test assembly are identified. • Test Resources Identified • Test IBD is complete
Test Planning Complete	• The test template is complete with the minimum 32 fields needed for a full test definition (procedures, configurations (resources), arbitrations, and data to be collected). See the MBSE Test Framework section for the template. • Where applicable, the set of requirements the test assemblies verify are represented in the model.

	• Personnel required for problem or failure debugging have been identified and have resources to support activities.
Test Ready	• The Test Assembly is sufficiently mature and stable in configuration to begin testing. • Test plan is complete, scheduled, and test resources are available. • When applicable for human testing, the Mishap Risk Assessments are complete.
Defected	• Test defeats found during testing and are in work to address them.
Verified	• The Test Assembly satisfied the arbitration criteria of the test and the requirements traced to them are verified.

11.6. Risk, Issue, Opportunity (Transitions) Review.

Prior to the review, the functional leads will ensure that the most updated risks, issues, and opportunities (ROI) are recorded in JIRA along with their mitigation plans. During the review, updates to the ROIs will be discussed.

11.7. Programmatic Review

The purpose of the programmatic review is to check the status of the contracts and MIPRs with respect to cost, schedule, and performance. The reviews will use the Cost Burndown model to assess the burn rates of contractor/MIPR expenditures. Additionally, a scheduling review will check the status of the IMS along with a critical path analysis that identifies each vendor's critical tasks. Finally, a status on the transitional opportunities the Contract/MIPR may provide will be reviewed.

12. Engineering Management Processes.

The Engineering Management Processes establish the procedures the JATF will use to design, test, integrate, and demonstrate the TALOS system. The following sub-sections describe each of the TALOS processes.

12.1. **Data Management.** The JATF uses the Confluence web-based software application as the team collaboration site. The purpose of Confluence site is to provide an environment for the TALOS Team and Partners to share information and execute knowledge management. The Confluence spaces is organized in a consistent manner with a minimum set of pages that must be managed. The site is organized into three work spaces (TALOS Engineering, Events, and Program Management). NOTE: This site is to support technical discussions. Proprietary data will not be posted that individuals/company are not willing to share under non-disclosure agreements (unless it is protected).

12.1.1. **TALOS Engineering Work Space**. This space contains all of the draft material and working documents. The purpose of this space is for the team to collaborate on documents and mature them to a point where they are ready for approval by the CHENG during an Engineering Review Board or an Engineering Synchronization meeting. Once documents are approved and re-baselined, they will then be loaded onto the TALOS Program Management Space. Each Integrated Product Team has their own working pages that will contain the following documents, at minimum:

- Documentation (SRD, MPRs, ICDs, schedules)
- Weekly Meeting Notes
- CAD Drawings

- Test Reports

12.1.2. **TALOS Events.** The space contains pages for events and design series meetings that are cross-functional. Pages include planning material, event data, and records of what happened during the event. Working items from the event are then migrated over to the TALOS Engineering Work Space for further refinement.

12.1.3. **TALOS Program Management.** This space contains all of the baselined configuration documents approved by the CHENG. Files in this space will not be modified until they have undergone the configuration management process.

12.1.4. **Version Control**. Files will be uploaded with the same file name. Confluence will automatically recognize the same file name and create a new version. Comments must be added that describe the changes that were made to the file. The following are the file naming conventions used to save files onto Confluence:

- Do not add dates to the file name – Confluence already registers the day it was added, and versions keep their dates
- Always capitalize TALOS in filename
- When using a system abbreviation, capitalize it: i.e. EXO, ARM, CHW, CSW

12.2. Decision Management. Within the Confluence Engineering Work Space, there is a Decision Table page that contains decisions made by the Chief Engineer (CHENG) for historical reference and pending future decisions. System-level decisions will be formally-tracked and decided by the CHENG via an Engineering Review Board. These decisions will be recorded in Confluence using the following table column header format:

Decision Creator	Decision in Question	Alternative Descriptions	Pros of Alternatives	Cons of Alternative	CHENG Final Decision Rationale	Decision Date

12.3. Risk, Opportunity, Issue, and Work Item Registry Management. TALOS will maintain registries for risks, opportunities, issues, and work items using JIRA. JIRA allows for custom classifications, tracking, filtering, and comment threads. The objective of implementing the JIRA management system is to ensure that our project is on track, can assign work, and hold assignees accountable. Definitions for these terms are as follows:

12.3.1. **Risks**: Something that has a chance of happening that will have a negative impact on cost, schedule, or performance. When a risk occurs, it becomes an issue. Each risk will have a consequence rating (1-5), a narrative description, and a likelihood rating (1-5). Each risk must have a mitigation plan that includes a collection of tasks. The risk description must be stated as an “If-Then” statement.

12.3.2. **Opportunity**: Opportunities are potential future benefits to the program’s cost, schedule, and/or performance.

12.3.3. **Issue**: Something that either has occurred or has a 100% chance of occurring and that has negative impacts to cost, schedule, or performance. Each issue will have a consequence rating (1-5) and narrative description assigned to either cost, schedule and/or performance. Each issue must have a resolution plan that includes a collection of tasks assigned to individuals with due dates.

12.3.4. **Work Item**: Engineering work that needs to be done by the TALOS team. Work items may include engineering designing, plan formulations, research, or collaboration that needs to be tracked at the TALOS Team level for everyone's awareness.

Risk, opportunities, issues and work items will be managed using JIRA in order to allow for comment threads. To create a ticket in JIRA, select the "Create" button at the top and, in the first field, navigate to "Project Management". The ticket with fields will auto-create. A single ticket form will be used for each item; however, only the following fields are required for each type:

Risk	Opportunity	Issue	Work Item
Summary	Summary	Summary	Summary
Priority	Priority	Priority	Priority
Area Impacted	Area Impacted	Area Impacted	Area Impacted
Description *(If/Then Format with Cost, Schedule and Performance implications)*	Description	Description *(Cost, Schedule and Performance implications)*	Description *(Include Due Date)*
Action Plan *(Mitigation)*	Action Plan *(Implementation)*	Action Plan *(Resolution)*	
Consequence		Consequence	
Likelihood			

These fields have been simplified to enable a single ticket format to be used in JIRA. Not all fields are required for all tickets, but the information described in parentheses above should be included.

The workflow for tickets typically follows the path below from left to right, although the ticket can be moved from right to left if needed.

To-Do → **In-Progress** → **Done** → **Resolved**

- **To-Do:** When any ticket is created, it is automatically placed in the "To-Do" bin.
- **In-Progress:** The ticket should be moved to "In-Progress" when the action plan is solidified for a risk/issue, the work item has been assigned a primary POC who begins to action the work or the opportunity is being actively pursued.
- **Done:** The ticket is "Done" when the action, mitigation or resolution plan has been implemented for risk, issues or work items or the opportunity has been leveraged or no longer applies.
- **Resolved:** The ticket is "Resolved" to clear it from the Kanban when it is no longer useful to be actively tracked by the program. This action will be managed by the Chief Engineer or his delegate.

12.4. Schedule Management. The Integration IPT lead will be responsible for the schedule management process and will be the custodian of the three Project schedules that comprise the Integrated Master Schedule (see the Schedule model section). Each Project schedule model will have custom dashboards that show the current ongoing tasks grouped by each vendor (to include TALOS). Functional leads will coordinate with the Integration IPT lead for model updates. The

Integration IPT lead will perform critical path analysis to identify potential schedule issues in the IMS.

12.5. **Hazard Management.** This plan documents the methodology to identify failures, isolate failures that are safety-related, and mitigate those hazards as part of the Systems Engineering (SE) process. The following paragraphs detail the tasks and activities required to implement a systematic approach to failure analysis, hazard analysis, and hazard management. The DoD Systems Engineering (SE) approach seeks to eliminate hazards, where possible, and minimize risks when those hazards cannot be eliminated. DoD Instruction (DoDI) 5000.02 defines the risk acceptance authorities. Military Standard (MIL-STD) - 882E covers hazards as they apply to systems, products, equipment, and infrastructure (including both hardware and software). MIL-STD-882E, Section 3.2 and all of Section 4, provides the minimum requirements for an acceptable system safety effort for a DoD system.

12.5.1. **TALOS Failure Analysis Process.**

12.5.1.1. **Identify Failures.** TALOS uses a form of failure mode and effects analysis (FMEA) to analyze the system (hardware and software, including COTS components) and its capability modules to identify potential failures. An Internal Block Diagram (IBD) specifies the internal structure, interconnections, data flow, and external connections for each TALOS capability module (CM). The Commands, Alarms, Status and States (CASS) document, when applicable, defines and describes the system modes, inputs, outputs, and behaviors associated with the CM. These two core documents form the starting point from which to conduct the FMEA. The team analyzes each connection within the IBD to determine the effects of a module/configuration item, wiring, or connection failure. The CASS document is used to inform the failure analysis process with detailed information about the function of the CM and how it behaves under failure conditions. In addition, the team refers to the TALOS CONOP tasks and accompanying SysML Activity Diagrams to brainstorm any failures that could occur during operational use from the operator's actions. For software-specific failures, the team also utilizes sequence diagrams from SEI to help inform the failure identification process.

12.5.1.2. **Analyze Failures.** Once potential failures have been identified, the information is combined to populate the primary fields of the Failure Analysis excel file, which are listed below:

- Identified Failure
- System Impact
- Indication
- Mitigation (Potential ways to minimize the probability of failure occurrence or severity of the failure)
- Type of Error (Critical or System)
- Potential Mishap (Indicate Yes or No)

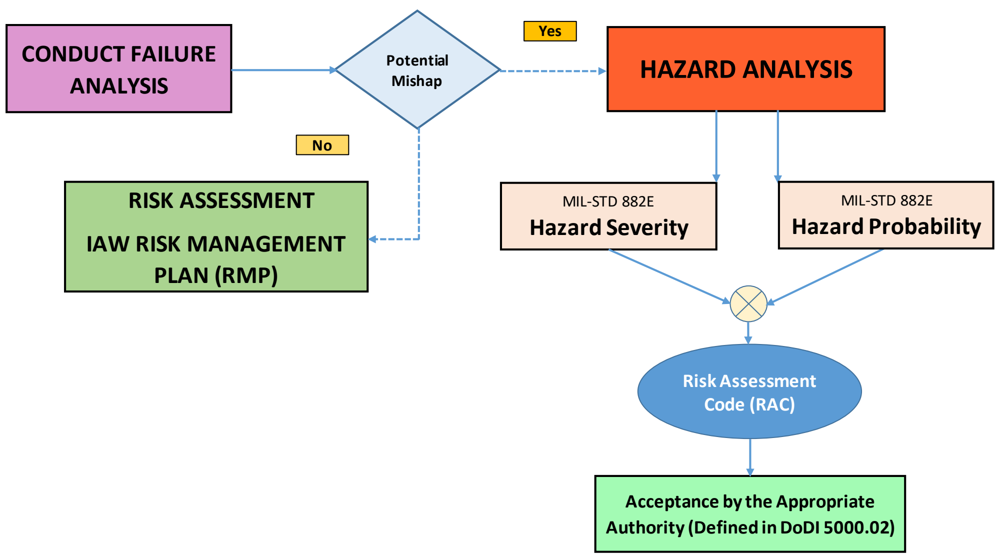
There are also secondary fields within the Failure Analysis file that, when populated, provide additional information to help manage and sort the failure database or to classify the priority and criticality of the failures:

- Severity
- Probability

- Detection
- Risk Priority Number (RPN)
- Configuration Item
- Work Breakdown Structure (WBS) #
- Notes

The team categorizes the failures on a scale of 1-10 according to the severity of the failure's effect, the probability of the failure's occurrence and the likelihood of detecting the failure should it occur. The Risk Priority Number (RPN) is a number used to identify and prioritize the most urgent failures for tracking and mitigation; the RPN is the multiplication of the severity, probability of failure, and likelihood of detecting the failure.

12.5.2. **TALOS Hazard Management Process.** Failures that have the potential to cause mishaps become hazards. Failures with no potential to cause mishaps are tracked as risks and are handled under the Risk Management Plan. A simplified flow-chart of this process is depicted below:



12.5.2.1. **Assess Hazards.** Software and hardware failures that result in a hazard are assessed as a severity that varies from Catastrophic-1 to Negligible-4. Probability of the hazard occurrence varies from Frequent-A to Improbable-E. Each hazard will have a potential risk mitigation measure identified. Based on available resources (time and money), the team may be able to implement one or more mitigation measures to reduce the hazard level. A mitigation measure will reduce the severity and/or probability of the hazard occurring. Then, the team again analyzes the residual hazard and the final, reduced severity and/or probability values to determine the risk assessment code (RAC). The RAC is an alphanumeric number determined by combining the intersection of the severity (rows) and probability (columns) (i.e. a RAC of 2D equates to a Critical hazard with a Remote probability). The RAC equates to a risk level of Low, Medium, Serious or High and is color-coded (green, yellow, orange or red).

12.5.2.2. **Document Hazard.** All TALOS hazards are documented in the Hazard Tracking System (HTS) and managed by the Test and Safety team. The HTS fields and their descriptions are listed below:

- Item ID
- Creation Date
- Hazard Title
- Functional Area
- Event (Test event or Review where the hazard was identified)
- Identified Risk Mitigation Measures
- Initial Hazard Severity
- Initial Hazard Probability
- Selected Risk Mitigation Measure
- Final Hazard Severity
- Final Hazard Probability
- Risk Acceptance Level
- Hazard Status (Open or Closed)

12.5.2.3. **Residual Hazard Acceptance.** The RAC documents the residual risk that remains after risk mitigation implementation. This residual risk must be accepted by the appropriate program authority

- Low: JATF TALOS CHENG
- Medium: Joint Acquisition Task Force Commander (JATF)CHENG
- Serious: Joint Acquisition Task Force Commander (JATF)
- High: USSOCOM SOF AT&L Acquisition Executive (AE)

Acceptance of the residual risk is formally acknowledged via the Mission Readiness Assessment (MRA), which must be completed and approved prior to each event in which a human has the potential to be subjected to the hazards associated with TALOS.

12.5.2.4. **Manage Hazard.** Failure and Hazard reviews will review and update the mitigation / handling plans, review pending risk acceptance, and closure of hazards, as needed.

12.6. Lesson Learned Management. The purpose of capturing lessons learned is to inform development opportunities for future variants of the TALOS system. An Excel file contains a registry of lessons learned that is managed by our civilian GHOST.

12.7. Configuration Management. Each model and system document will have a design authority source and a custodian that will gather and cross-reference inputs from design authorities. Review boards that will re-baseline models will occur during the Engineering Synchronization meetings and or Integration Work Sessions. The following table designates the design authority and custodians for the TALOS models and documents.

Model or Document	Design Authority	Custodian
Business Models	Director	GHOSTs
Performance Models	CHENG	MBSE Team and GHOSTS
Schedules	CHENG	Integration Team Lead
Cost Models	PM	GHOSTs
System Requirements Document (SRD)	CHENG	Requirements Management Team Lead
Modular Performance Requirements Document	Functional leads	Requirements Management Team Lead
Master Test Procedures Document	Test Lead	Test Lead, MBSE Team
CAPEX Demonstration	Director	Test Lead and Operators

13. Engineering Tools.

The following table outlines the tools used by TALOS.

Engineering Tool	Purpose
MagicDraw	Models the TALOS Architecture and is the one source ground truth of system specification.
Microsoft Project	Manage, track, and analyze the Integrated Master Schedule
Confluence	Web-based collaboration application.
JIRA	Manage Risks, Opportunities, Issues, and Work Item Registries
Excel and PowerPivot Excel Add-on	Primary tool for models and exports from MagicDraw within the TALOS modeling architecture
Solidworks	Computer Aided Design software use for design specifications of CIs

14. Model-Based System Engineering Methodology (MBSE).

This section covers model-based techniques and the TALOS MBSE methodology to achieve the typical goals of systems engineering for product integration and validation by using computer tools.

14.1. **MBSE Scope and Background.** The MBSE approach is designed to work with an existing state of play and transition MBSE work into an already-moving project. Further, it is understood that TALOS is an effort to deliver an integrated, TRL 6 exoskeleton with military hardware. This means that the effort is not for a production system for direct fielding. There are, however, multiple vendors supplying hardware and software that must eventually be integrated in multiple ways in order to work. The integration is also across multiple layers of hierarchy, which indicates that there are potential distant effects and cycles to be concerned with. These observations indicate a need for a "just enough" style of systems engineering rather than the style typically applied by prime contractors such as Lockheed Martin or Boeing. The contrast to be made is that a delivered system is expected to be delivered somewhat hands-off to the end user to be used in many environments without technical knowledge. A TRL 6 system can be successful while surrounded by knowledgeable technicians to coax performance over a series of relatively short, pre-arranged periods.

This means that the model is not intended to ward off all possible adverse interactions, save those that are safety critical, or provide a sustained knowledge base for continued operation and update. Rather, the goal should be to provide trusted artifacts that record agreements between multiple technical authorities. These trusted records are intended to assure:

- Details are not forgotten in a high-speed effort
- Decisions previously made are not re-litigated without a driving need
- Information crosses between performers that do not share a direct programmatic connection (e.g., EXO structure provider to C4I computing box building)
- Constrained resources (e.g., areas on critical panels, Ethernet switch ports) are tracked carefully and remain responsive to changes
- Activities with a highly compressed schedule or many activities in parallel are initiated with all required inputs so as not to incur impactful delays
- Last-minute changes with safety implications are not made without a look at all side effects

14.2. System Modeling. System models focus on the interrelationships and cooperative behavior of the parts of an existing or planned system. This makes them different from typical engineering models that attempt to explain or replicate specific dynamics such as mechanical motion or control laws. Informal system models such as flowcharts or block diagrams graphically display and trace the connections between discrete elements. Formal system models add a layer to this by using a restricted, agreed-upon vocabulary to use for discussion and reasoning. For example, the various aggregation levels of “system,” “subsystem,” “assembly,” “component,” and “part” are often given specific meanings that have consequences for test and integration. A standards-based system model will take this one step further and place control and maintenance of this vocabulary in the hands of a standards body. Finally, these models can be developed by hand with documents and stencils or via a dedicated computer tool that may also support configuration management and rule-checking.

14.2.1. **Three Pillars of MBSE:** The three pillars of MBSE involve a modeling language, a methodology, and modeling tool.

- **Modeling Language**. The JATF TALOS uses the SysML; SysML is a visual language with a common semantic and notation standard that facilitates MBSE.
- **Methodology.** An MBSE methodology is a road map of tasks that is applied to a specific domain or organization. The purpose of this section is to define the methodology JATF TALOS will use.
- **Modeling Tool**. A modeling tool is a software application that conforms to one or more modeling language and integrates all modeling artifacts into a cohesive system reference model. JATF TALOS uses Magic Draw.

14.3. Problem Statement and Objectives. The MBSE approach intends to target specific problems with effort objectives. This explicit map intends to avoid doing modeling work for the sake of doing work, but rather target specific project needs. As described before, these objectives are further tailored to a project intending to deliver an integrated system at TRL 6. Thus, the effort will be tuned to identifying, tracking, and closing specific technical work items, along with providing visibility of said work to project leadership and advocates. This contrasts with a larger effort that would be intended to cover a full lifecycle that includes stakeholder requirements elicitation and high-level architecture development. The below table shows a collection of problem statements and MBSE objectives that address them.

Problem Statements	MBSE Objectives that Address the Problem
Need for a shared understanding of the test and integration T&I plan and schedule across all stakeholders (leadership, functional areas, and vendors).	1. Autogenerate Module Performance Documents (MPRs), Interface Control Documents (ICDs), and RVTMs 2. Produce and maintain a map of delivery configuration items (CI's) to integration and functional tests 3. Maintain a list of assemblies made specifically for test and link to CI's required to create assembly 4. Capture individual interfaces and connections to support the burndown of interface definition and validation work 5. Autogenerate burndown lists and status as needed for interfaces, requirements to verify, and other items as needed.
Rapidly changing design and integration environment that requires an agile approach.	6. Provide an "authoritative source" of information such that when two depictions of the system conflict, a determination of the current version can quickly be made. Provide direct references between system element, status (e.g., baseline), and authority (if baseline or revision to baseline). 7. Establish a model release cadence that provides some stability while remaining responsive to change (e.g., once a month) 8. Release technical data updates as deltas rather than "data dumps" without context 9. Support Engineering Review Board with reports on set of items that may need design review / revision as result of a given change
Need for a clear status of the test and integration plan with respect to planning, execution, adaptions to change, and impacts of test failures.	10. Provide traceability between software messages generated to stimulate test, consumers of messages, and status of defects and repairs due to testing 11. Capture as-tested configurations including key support equipment 12. Capture as-tested modifications to hardware, firmware, and software to provide situational awareness to other functional areas
Support the verification plan to provide objective evidence that the TALOS system and system components fulfills their specified requirements and characteristics. Support the validation plan to ensure TALOS fulfills its CONOP tasks in the intended environment.	13. Drive a clear definition of observables to be tested that support requirements verification 14. Provide a lightweight functional allocation to assure coverage of CONOP-supporting functions during integration and functional area testing
Need for safety standard compliance.	15. Track safety-critical test and configurations and use the model to check for changes that may break safety-approved configurations

15. MBSE Test Framework.

For each of the test assemblies, TALOS will utilize an MBSE test framework to derive the tests that will be performed and record the results of the test. Appendix B contains the data elements that comprise the test framework. The framework consists of the following four aspects: Procedure, Configuration, Arbitration, and Data. Additionally, a test instance element contains all the details of a specific test (one of many).

15.1. **Test Procedures.** Test Procedure defines the detailed procedures and sequenced steps to execute the test via the method behavior of an operation as well as other relevant procedure information

15.2. **Test Configurations.** Test Configuration describes the hardware, firmware, and software test equipment, support items, and facilities needed to conduct the test event. The test assembly/test article being tested may differ from the final WBS element due to additional interfaces required to enable the test therefore a new WBS element that is a specialization of the original is created. Test Assembly IBDs describe the specific ports and connections between parts of the test configuration.

15.3. **Test Arbitration.** Test Arbitration describes the aspects of the test event, including the characteristics and criteria of what is being tested as well as margins and verdicts (e.g. pass/fail) of the results. Predefined constraint blocks define the inequality relationships of the characteristics and criteria and are used to aid in automated arbitration of the measured characteristics against the criteria. Parametric diagrams connect characteristics of the test article (representing the actual values), the verification criteria, and the margin and verdict of the arbiter to the constraints

15.4. **Test Data.** Test Data describes the kind of data that will be collected in the course of the test. Predefined constraint blocks can be used in converting the test data into a useable form for arbitration

15.5. **Test Instances.** The Instances package contains Procedure, Configuration, Arbitration, and Data packages each containing instances of the aspects of the test architecture. Instance tables are used to create and present details of the specific test equipment, test article tested, facilities used in the test as well as the personnel who conducted the test. Instance tables will also be used to present the data recorded during the test and view arbitration results.

Definition of Terms

Identifier: A key value assigned to a system element used to relate the collection of TALOS models.

System Element: A member of a set of elements that constitute the TALOS system. Types of system elements are structural, behavior, requirements and their features.

Behavioral Elements: Use Cases, Activities, Interactions, and State Machines. See the MBSE section for detailed definitions.

Structural Elements: Hardware and Software Configuration Items (CIs), Assemblies, Test Assemblies, Test Resources and Interfaces. Each element will have an identifier that will act as the key value for all of our models.

Configuration Item (CI): The fundamental structural hardware, software, and test resource elements of the TALOS configuration Management system. CIs are delivered to TALOS by vendors and will be managed to ensure they are specified to the appropriate level and have defined interfaces. Controlled information includes:

- Identifier
- Name
- SWaP parameters
- Jacks and mounts
- Loaded Software services and host

Assembly: a combination of *CIs* and *lower level assemblies* that form an organized aggregated structure within the TALOS system. Controlled information includes:

- Identifier
- Name
- SWaP parameters
- Jacks and mounts
- Loaded Software services and host
- Composed hardware and software
- Interfaces connected between composed hardware and software

Test Assembly: a combination of *CIs*, *lower level assemblies*, and *test resources* that form an organized aggregated structure within the TALOS system. Test assemblies will equate to the test articles within the TALOS MBSE Test Framework. Controlled information includes:

- Test Article
- Test date
- Test facility used
- Test equipment used
- Test support equipment used
- Pass/Fail arbitration with course of actions if we fail

Test Resource: a structural element within a test assembly that represents the discrete resource needed to perform a test.

Interface: A shared boundary between to system elements that are categorized as physical, logical, and electrical.

Physical interface: a system element that binds physically two system elements.

Logical interface: a system element that passes information from one element to the other.

Electrical interface: a system element that joins electrical terminations to create an electrical circuit.

Failure: An event in which the system or sub-system does not perform as specified or expected, either due to a mechanical/hardware failure, software failure or the actions of the operator. A failure can be caused by two types of errors:

> **Critical Error:** Prevents the system from basic operation. Presents a life-threatening safety concern to personnel or irreversible damage to hardware.
>
> **System Error:** Degrades performance, but does not prevent basic operations or pose a serious safety concern to personnel.

Hazard: A real or potential condition that could lead to an unplanned event (i.e. mishap) resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

Mishap: An event resulting in equipment damage in excess of $20,000 or illness/injury to personnel that requires medical treatment beyond first-aid (per OSHA 1904.7 - Recording and Reporting Occupational Injuries and Illness).

Risk: An event that has a probability of occurrence less than one, with negative impacts on cost, schedule or performance.

Appendix A: TALOS Objective Mapping to Technology Areas of Interest

The TALOS vision orients around four tenants (increase survivability, human performance, situational awareness, and lethality). Within each tenant there are sub-objectives that characterize what the JATF intends to achieve in order to realize the TALOS vision. The table below maps the TALOS technology areas of interest to these sub-objectives.

<table>
<tr><td colspan="2" rowspan="4">INCREASE SURVIVABILITY
1.1 – Design and develop materials, devices, systems, and/or structures
to support next-generation ballistic, blast, and whole-body protection. Minimize weight and bulk, while providing protection against advanced rifle rounds. Face/head protection and ergonomic fragmentation protection are of high interest. The ability to rapidly obtain National Institute of Justice-certified ballistic test results on small samples of new armor materials is desired.</td><td>Increase Helmet Protection
1.1.1 – Transparent ballistic materials suitable for use as a helmet visor with minimal optical distortion or low optical index in order to provide full-face protection against advanced rifle rounds without operator discomfort or distraction.
1.1.2 – Fully-enclosed armored helmet system made of an opaque material that allows the operator to maintain full situational awareness.
1.1.3 – Technologies that minimize traumatic brain injury and/or injuries from back-face deformation of ballistic protective devices.</td></tr>
<tr><td>Increase Vital Area Ballistic Protection
1.1.4 – Technologies capable of providing protection against advanced rifle rounds with additional embedded capabilities such as sensors, transmitters, power transmission, etc.</td></tr>
<tr><td>Increase Extremity Protection
1.1.5 – Designs that afford maximum body coverage, including the dynamic/junction regions, and defeat the highest small-arms threat possible while maintaining freedom of movement.
1.1.8 – Technologies that assist with mounting ballistic material and other subsystems to dynamic structural components.
1.1.9 – Lightweight, flexible technologies to protect SOF operators from fragmentation and ballistic threats.</td></tr>
<tr><td>Reduce Operator Signature
1.1.6 – Technologies that aid in concealment from observation by the enemy.
1.1.7 – Technologies to reduce electromagnetic and acoustic signature.</td></tr>
<tr><td rowspan="2">INCREASE HUMAN PERFORMANCE</td><td rowspan="2">Enhance Powered and/or Passively Actuated Combat Suit
1.2 – Develop unique tactical exoskeleton systems for use in a dynamic, austere environment. A complete proposed solution should incorporate all components necessary to create an operable exoskeleton (joint-level, lower-body or full-body). Approaches could be powered or unpowered. Both</td><td>Augment Strength
1.2.2.2 – Improve operator strength.
1.2.3 – Powered high-efficiency actuation solutions that provide consideration for thermal management.</td></tr>
<tr><td>Increase Carrying Payload
1.2.1.1 – Carry its own weight, plus a nominal 75lb distributed payload (without actuation).
1.2.2.1 – Carry its own weight, plus a nominal 150lb+ distributed payload (with actuation).
1.2.2.4 – Provide consideration for interfacing with full armor coverage.</td></tr>
</table>

	platforms should be capable of walking through a standard 30" x 66" marine hatch with a 6" vertical threshold, while keeping the operator's hands unencumbered by the structure, enabling coarse and fine motor skill manipulation of the environment and suit.	**Minimize Reduction in Mobility and Agility** 1.2.1.2 – Be fast, agile and allow the operator to sit normally. 1.2.2.3 – Provide consideration to auto-stabilization. 1.2.2.5 – A conformal, efficient, and tightly packaged exoskeleton design of the structure, actuation, sensing and control network that minimizes size, weight and power. 1.2.4 – Customized footwear that integrates exoskeleton structural components, actuation concepts, and sensors for motion prediction.
		Maximize Mission Duration 1.5 – Develop technology related to power generation, power management/ monitoring, and energy storage. These technologies are necessary to provide an uninterrupted source of power to an untethered SOF operator. -- 1.5.1 – Wearable, small backpack size or smaller, preferred body distributed (<50 lbs), fuel-efficient power sources with noise levels <60 dB and capable of providing up to several kilowatts of clean DC power for multiple hours. Sources should be less than 120VDC and not to exceed 600VDC, although short-term load peaks above this level are possible. -- 1.5.2 – Technologies governing the management and control of power distribution to TALOS subsystems at multiple voltages. -- 1.5.3 – Technologies pertaining to thermal management, vibration mitigation, & acoustic signature mgt.
	Enhance Biomechanical Data Capturing and Modeling 1.6.6 – Technologies leading to methods of biomechanical motion capture & kinematics in SOF relevant environments. 1.6.8 – Biomechanical modeling and simulation tools for prediction of movement characteristics and performance impacts of developmental personal equipment on the dismounted SOF operator.	
	Enhance Biomedical Monitoring and Thermoregulation 1.6 – Develop technologies that focus on man-machine pairing to optimize human. performance	**Enhance Operator Thermal Management** 1.6.2 – Active thermal management technologies that can be worn with operational kit by dismounted SOF operators. 1.6.3 – Novel garments and technologies for passive thermal management that can be worn in conjunction with SOF operational kit.
		Enhance Physical and Cognitive State Monitoring 1.6.1 – Technologies that enhance the physical and cognitive capabilities of the SOF operator. 1.6.4 – Technologies to measure operator physiological status, including electro-cardiogram, respiration, core body temperature, blood pressure, etc. during SOF operations. 1.6.5 – Technologies to monitor physiological status to predict operator physical and cognitive performance during SOF operations.
		Enhance Medical Intervention 1.6.7 – Suit integrated/remotely deployable advanced medical intervention devices (e.g. tourniquets, auto injectors, etc.).

INCREASE SITUATIONAL AWARENESS	**Enhance Visual/Audio Awareness** 1.3 – Develop technology that ensures the TALOS operator is fully aware of his environment through enhanced situational awareness presented via multiple senses.	**Enhance Entity Disposition Display** 1.3.4 – Provide an informational display or see-through stereoscopic heads-up displays and micro-opaque displays. -- 1.3.4.1 – Transparent near-eye displays capable of mounting behind night vision devices. -- 1.3.4.2 – Narrow-wavelength near-eye projection displays (monochrome or color). -- 1.3.4.3 – Low optical distortion, transparent near-eye display capability. -- 1.3.4.4 – See-through fields of view in excess of 100° horizontal. 1.3.5 – Control display interfaces without physical manipulation.
		Maximize Peripheral Sensing 1.3.3 – Maintain 360° visual field of view in both azimuth and elevation.
		Enhance Multi-Spectral Imagery Display 1.3.6 – Display multi-spectral imagery on a see-through display.
		Enhance 3D Audio Awareness 1.3.2 – Capture sound from 360° and digitally recreate the sound in both azimuth and elevation.
	Enhance Information Awareness 1.4 – Develop technology to provide robust comm and a computing platform to serve as TALOS' central processing system. Provide man-worn networked ISR; non-RF comm; beyond-line-of-sight (BLOS) comm, computer vision, decision support, and data fusion.	**Enhance Voice and Data Communications** 1.3.7 – Wireless control capabilities, specifically in the areas of near-field magnetic induction, near-field communication, or Institute of Electrical and Electronics Engineers (IEEE) 802.11ad wireless technology. 1.4.1 – Open architecture systems that allow portability of waveforms and wideband/ultra-wideband (e.g. WB/UWB, 60GHz, etc.) communication. 1.4.3 – Provision of high-bandwidth non-RF communications with reduced signature and low power requirements. 1.4.6 – BLOS communication in an unobtrusive, man-worn form factor. 1.4.7 – High-bandwidth BLOS communication in contested environments. 1.4.8 – Secure, low-profile, wireless in-helmet communications.
		Increase Portable Computer Processing Capacity 1.4.10 – Wearable, semi- to fully-ruggedized, high-speed computing/networking with its own, less than 5 lbs, power source.
		Increase Signal and Signature Detections 1.4.2 – Man-worn form factors that collect battlefield signals and signatures of interest, such as the detection of combatants, weapons systems, explosives, mobility platforms, unmanned systems and/or ISR assets. 1.4.4 – Provision of signatures for highly-used entry/exit locations and internal layouts of buildings. 1.4.5 – Imaging through walls and other solid surfaces in a man-worn form factor.

		Enhance Targeting Data Fusion and Interpretation 1.4.9 – Target recognition and computer vision to augment the ability to recognize and engage targets and to aggregate and analyze data and information on items of interest. 1.4.11 – Data fusion related to targeting, ISR, and the development of real-time, fused, multi-intelligence products with reduced bandwidth requirements for transmission. 1.4.12 – Decision support tools that help interpret, present and manage data with the objective of reducing the cognitive load on the operator.
		Enhance Geospatial Awareness 1.3.1 – Provide wearable pedestrian navigation and/or Simultaneous Location and Mapping (SLAM) outside of imaging wavelengths (not in the range of 300nm to 12nm). -- 1.3.1.1 – Echo-location mapping. -- 1.3.1.2 – Microwave Doppler imaging.
INCREASE SURGICAL LETHALITY 1.3.8 – Improve targeting system to shorten the decision chain and increase accuracy.		**Augment Target Detection, Acquisition, and Identification** 1.3.8.1 – Virtual reticle capability. 1.3.8.2 – Capabilities to rapidly aim a weapon system without emitting illumination or requiring the operator to directly view weapon-mounted sighting systems.
		Increase Lethal Accuracy 1.3.8.3 – Systems which enable visualization of projectile flight path. 1.3.8.4 – Systems that stabilize weapon platforms and reticle for increase accuracy.

Appendix B: MBSE Test Framework Data Elements

Context Block	Context Block Comments	Block Element	Block Element Comments	Value Properties	Value Property Comments	Category
				Test Name	A brief name of the test event	**Initial Entry**
				CI Id(s) Tested	A list of the Configuration Items id(s) being tested	**CIs Identified (includes SW)**
				Requirement Id(s) Verified	A list of the requirement id(s) being verified by the test	**When Appropriate**
				Test Objective	A high-level description of the objectives and success criteria for the test	**Initial Entry**
				Test Type	Analysis, Inspection, Demonstration, Test	**Initial Entry**
Test Procedure Context	TestProcedureContext provides the context for the definition of the detailed procedures and sequenced steps to execute the test via the method behavior of an owned operation as well as other relevant procedure information such as test dates and number of measurements.			**testCase**	A detailed description of the procedures, sequenced steps, and all operations required to complete the test. Can include how many times a particular characteristic will be observed.	**Procedures**
Test Configuration Context	TestConfigurationContext provides the context for the description of the hardware and software test equipment, support items, facilities, and personnel needed to conduct the test event.	**testEquipment**	The hardware test equipment used to stimulate, measure, and/or record test data	**name(s)**	A list of the names of the test equipment	**Test Resources**
		testSupportEquipment	The hardware items that are used to add realism to the test.	**name(s)**	A list of the names emulators	**Emulators**
		testFacilities	The facility where the test will occur	**name**	The name of the test facility location	**Test Location**
		testPersonnel	The individuals who participate in some capacity in the planning, certification, support, and execution of the test event.	**name(s)**	A list of the personnel needed to perform test	**Test Personnel**
Test Arbitration Context	TestArbitrationContext provides the context for the arbitration of the actual, observed characteristics of the system under test against the required characteristics.	**TestAssElement Characteristics**	Characteristics and design criteria of the TestAss Element SUT(s) to be inspected or tested	**observableCharacteristic(s)**	A list of observable (and in most cases measurable) characteristic(s) of the TestAss element SUT(s) in the form: <characteristicA,characteristicB,etc.>. The characteristic can be a performance attribute, physical characteristic, interface characteristic (e.g. signals or messages received/sent), or behavioral characteristic. The order of the list should match	**Observables**
		verificationCriteria	Values of the characteristics and design criteria to be inspected or tested.	**verificationCriteria(s)**	A list of the required values of the characteristics in the form: <TestAssId, characteristicName, requiredValue1,requiredValue2,requiredValue3,etc.>. If the observed characteristic must be within a certain range or tolerance than requiredValue1 = lower limit, requiredValue2 = upper limit	**Verification Criteria**
Test Data Context	The TestDataContext provides the context for the description of the kind(s) of data that will be measured and collected in the test execution and how that data will be transformed into a useful form for arbitration.			**observedCharacteristic**	A list of the actual values of the characteristics in the form: <TestAssId, characteristicName, value1,value2,value3,etc. (if applicable)>. Rather than input the values here, it might be appropriate to reference the file on Confluence containing the test data in the form: <TestAssId,characterisiticName, ConfluenceHyperlink>	**Observed Characteristics (after test)**
				TestConclusion(s)	A list of test conclusion(s), i.e. paragraphs	**Test Result Conclusions**