You want to fly What Kind of Hardware?

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Hardware Types

• Hardware Categories
  • Information Technology (Computers: Phones, tablets laptops)
  • Custom Developed
  • General Use: Modified commercial product, referred to as MOTS
  • COTS

• Each category has its own set of challenges.
• Bad news is ISS is filled with requirements that are seemingly designed to only be understood by those extremely close to the program.
• Good news is all categories have seen a relaxing of requirements in general.
Generic Challenges

• Material Compatibility
  • If the product is extremely small it is not a concern.
  • Stay away from thin brittle plastics
    • If 3D printing Ultem is the only approved plastic.
  • Gels, Solvents: No alcohols
  • Use conformal coating and treat capacitors as toxic, design to contain.

• Electromagnetic Compatibility
  • Avoid magnets
  • Requirements have heavily relaxed below 100 MHz
  • Start intentional transmitter discussion early.
    • Standard Bluetooth okay
Generic Challenges

• Batteries
  • Custom battery designs are ill advised.
  • Even COTS solutions must be lot tested
  • Button cells, alkaline have no circuit design constraint, all others do.
  • Do not develop a custom piece of hardware that charges a Lithium cell, testing will destroy multiple units, not just the cell is damaged but the hardware as well.

• Acoustic
  • Stay under NC 34
  • Or 59 dBA, it is limited to 2 hours of operation per 24-hour period

• Microgravity
  • Items with single axis accelerometers are ineffective, Triaxial needed
Generic Challenges continued

• Structures
  • For portable equipment the only real concern is kick loads.
  • But if the item is controlling a safety hazard, fasteners must be tested.

• Thermal
  • Consider small fans to aid in heat rejection
  • Touch temperature

• Containment: Liquids, Toxins, capacitors etc
  • Tox level hazard dictates the number of redundant levels of containment.

• Servicing of hardware how easily can the hardware be repaired or subcomponents replaced (Orbital Replaceable Unit (ORU))
  • Use of captive fasteners

• Human Factors
  • Usability for a wide range of sizes of humans
IT Hardware

• The ISS program provides a suite of IT equipment, overall the rationale to fly a custom piece of IT equipment makes this challenging enough.
  • Currently the primary station laptop is a Lenovo T61p model but being changed shortly to a Z-Book.
  • Any attempt to fly a different COTS based solution will be frowned upon.
    • The station community and crew office does wants little variety of products to minimize crew training and maximize throughput.
  • If another asset is required, note no spares will be available in the pantry.
    • Radiation testing of these types of assets is essential to mitigate risks.
    • System must permit remote virus definition updates if any data is to interface with station assets.
• Suite includes Ipads with different IOS (use of such devices is discouraged)
  • The station architecture due to security requirements does not interface with the apple store
  • If an IOS based device is absolutely essential to your science data gathering work will be required to update the application as certificates and operating systems expire or are upgraded
    • If the application suite requires a server to gather data, minimize interaction with server.
• If you are flying IT hardware you undoubtedly will be flying software.
  • Software performance requirements are easy.
  • Software documentation and configuration management requirements are arduous.
    • NPR 1750.2 treats all “flight software” as class C or better
      • Previously payload experiment software was class D.

• ISSMP will provide guidance on what the requirements mean and also how to meet their intent with minimum cost.

• PI software development should include the capability how to downlink data to the ground.
Custom Developed

• If custom developed hardware is required, emphasis should be on minimizing the crew participation for setup and maintenance.
  • Think automation outside of necessary data gathering
  • Crew training is not necessarily time intensive, and often scheduled many months before flight. Also crew time onboard is at a premium complicated tasks are hard to plan and impact console support times.
  • Remember that the longer it takes to obtain science data, less chance it will be obtained.

• Custom developed hardware should assume a 2 year development / integration window.
  • With no heritage of COTS, the process of approval of the system through the safety organization is difficult particularly if there is a direct invasive interface with the crew for obtaining crew physiological data.
  • ISSMP participation is needed very early in this development process to assure smooth integration and verification.
General use MOTS

• General use hardware that has been customized invariably gets labelled at MOTS
  • Asking vendor for custom mods is a great solution.
  • Most vendors will work with us
    • Simple things to consider are
      • Conformal coating, removing paint
    • More complicated items are
      • Replacing connectors to a SCOOP proof variety, changing the housing
      • Consider servicing related changes, like battery change out or cleaning methods
  • The more things done by the manufacturer the better for the overall risk and better warranty support.
    • Avoids questions of tampering or voiding the FDA approval
• This is largely the most flown type of hardware.
COTS

• For simple projects this is a perfectly fine alternative

• Tremendous upside to buy and fly.
  • Excellent choice for items developed for exercise where a great deal has been invested in the product being ruggedized and weather resistant.

• Many DoD products have been commercialized by vendors, which generally means they sell to aviation and marine communities already

• Be careful of these products in materials compatibility since the ISS environment is very closed loop.
Why it is best to work with ISSMP Early

• We know:
  • How to make the hardware compatible with current ISSMP hardware.
  • ISS architecture
    • Particular important when designing a piece of hardware to know its use environment.
    • ISS is not like your lab at all.
  • Interfaces:
    • Power is limited to really just 28 V DC and some access is being provided to 120 AC
      • The 120 V AC must be floating neutral compatible, amongst other considerations
      • USB 5Volt power for rapid charging coming in 2017.
  • Data
    • Most like the lab in terms of options; Ethernet(including wireless), USB, Bluetooth and RS - 422.
Why it is best to work with ISSMP Early

• Why duration from selection to flight is "so long”.
  • Program interfaces
    • Non-HRP payloads have to get a Payload Integration Manager (PIM), we are our own PIM
    • Planning and development for operations and related products
      • Verification plan development, submittals and closure
      • Manifesting
      • Stowage
      • Crew time resources
  • Safety related process
    • 45 days from package submittal to actual review and can be multiple reviews.
  • Human Factors and labelling reviews
  • Certification process

• New development process Class I-E allows faster from ground to flight.
Good News

• A relatively new development process 1-E allows faster from ground to flight The new process is for non-critical experiment hardware
  • Allows ISSMP to quickly turn around lab like products to flight products.
    • Relax the detailed drawing requirements
    • Decreases the amount of documentation
    • Allows the procurement from unlimited suppliers (direct from China still not permitted).
    • DOES NOT RELAX SAFETY.
    • Allows direct to lab flight procurements.
    • Effectively takes away the unnecessary NASA slow down of receipt and fabrication

• Near term additions of AC power options
  • Will allow use of standard COTS AC powered items to be flown relatively as is.
    • Must be floating neutral compatible
    • UL listed, with ground wire
    • GFCI compatible
Requirements

• Most often hardware that is procured or developed by ISSMP is because of clearly defined REQUIREMENTS
  • Clearly defined is not always easy:
    • A product suite that was used in our lab is helpful:
    • Key requirements for science
      • ISSMP Engineering will take everything else in consideration.
  • ED requirements lead to hardware requirements documents

• Design reviews and Team meetings are your friends
  • Review, evaluate and participate.
    • Compare ED to hardware requirements documents for gaps.

• We deliver 6 months after the final review.
• Science Verification Test is your final hardware acceptance.
Take Away

• IT hardware development is expensive and the use of common IT resources is strongly encouraged.
  • IOS discouraged STRONGLY
  • Deployment and other constraints make stand-alone IT developments challenging
  • If specialty IT hardware is required, avoid a direct interface to ISS avionics environment make it into an embedded system with the rest of the experiment architecture
  • Software best addressed thru a browser based interface

• Repacking COTS devices into a MOTS products is likely best done by the ISSMP team with technical inputs from the PI Team.

• Custom built hardware, after design complete recommend ISSMP personnel build and test flight units as Class I-E.

• COTS hardware best procured and final delivery by ISSMP personnel as Class I-E.
• All softgoods should be planned to be designed and manufactured by ISSMP.
Things to add

• Pictures