

Manufacturing Nuclear Weapon “Pits”: Paths toward 80 Pits Per Year

Presentation to
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Pit

- Fissile core of a nuclear weapon
- Uses plutonium
- Detonates the secondary stage
- No pit, no weapon

A Sisyphean History

- Cold War mfg capacity: 1,000-2,000 war reserve (WR) pits per year (ppy)
 - WR: pits accepted for use in the stockpile
 - Rocky Flats Plant halted ops in 1989
- Many facilities proposed since 1989
 - NMSF, Building 371, MPF, CNPC, Complex 2030, CMRR-NF
 - None succeeded
 - Two (NMSF, Bldg. 371) were built and torn down
 - No new plutonium processing facilities brought online since 1978 (PF-4)

Pit Manufacturing Capacity

- Zero since June 2013
 - PF-4 ops paused due to concerns over criticality safety and formality of ops
 - LANL working to restore PF-4 pit mfg to operating status
 - Equipment, processes, people for mfg are available
 - Also, no requirement to manufacture WR pits
 - Therefore, some quality assurance processes to certify pits as WR have been suspended

80 ppy: Now Required by Law

- DoD requirement
- Some argue for higher or lower numbers
- But P.L. 113-291, FY2015 National Defense Authorization Act:
 - In 2024, manufacture 10 WR pits
 - In 2025, manufacture 20 WR pits
 - In 2026, manufacture 30 WR pits
 - For 3 months in 2027, manufacture at rate of 80
 - May be delayed 2 years if DoD, DOE report justification

What's Needed to Manufacture 80?

- Manufacturing tasks
 - Material prep, pit fabrication, material control and accountability, quality control, waste mgmt, etc.
 - All tasks entail Material At Risk (MAR) and space
 - **MAR**: “The amount of radioactive materials (in grams or curies of activity for each radionuclide) available to be acted on by a given physical stress.” (DOE)
 - **Space**: laboratory floor space suitable for ops

Margin

- $\text{Margin}_{\text{space}} = \text{Available}_{\text{space}} - \text{Required}_{\text{space}}$
- $\text{Margin}_{\text{MAR}} = \text{Available}_{\text{MAR}} - \text{Required}_{\text{MAR}}$
- These produce static, point-in-time numbers

Calculating Margin: Is There Enough?

- Critical question for Congress, NNSA, DoD
- “Enough” = margin > 0
- Need 4 numbers:
 - 1. MAR available for mfg
 - 2. MAR required for mfg
 - 3. Space available for mfg
 - 4. Space required for mfg
 - These numbers can change over time
- 1 and 3 are available (may need updating)
- 2 and 4 have not been calculated rigorously for 80 ppy, so cannot know how much is enough

Margin and Uncertainties

- Uncertainties may creep in over time, affecting availability and requirements for MAR and space
- Thus need margin to offset uncertainties
- Examples of uncertainties
 - Requiring more ppy increases demand for space, MAR
 - A new regulation reduces available MAR
 - Removing unneeded Pu from PF-4 increases available MAR
- More examples ...

Uncertainties, over Decades, May Alter Space and MAR Required and Available for Pit Mfg

	Factors	Example 1	Example 2	Example 3	Example 4
1	Factors increasing supply (availability) of MAR	Develop and install means to increase PF-4 seismic resilience	Clean out PF-4 vault, store more Pu needed for ongoing work in vault	Remove unneeded plutonium	New interpretation of a regulation permits increased MAR (as with RLUOB)
2	Factors reducing supply (availability) of MAR	A previously unknown seismic fault is discovered at TA-55	New interpretation of a regulation tightens restrictions	Cracks in concrete from earthquake reduce confidence in PF-4	Defense Nuclear Facilities Safety Board raises concern about an existing procedure
3	Factors increasing supply (availability) of space	More efficient use is made of PF-4 basement; some lab operations are moved there	Build modules	Clean out and repurpose rooms in PF-4	Add shielding around gloveboxes, permitting more in a room
4	Factors reducing supply (availability) of space	Add non-pit mission in PF-4	Pit manufacture uses more equipment than previously thought	A new regulation requires increasing space between gloveboxes to reduce dose	Contamination from an accident prevents use of a room in PF-4 for some time
5	Factors increasing demand (requirements) for MAR	Requirement changed to 125 ppy because of geopolitical developments	Faster process exposes more MAR	Partial collapse shuts CMR; its plutonium is moved to PF-4	Problem in a deployed weapon brings more pits to PF-4 for analysis
6	Factors reducing demand (requirements) for MAR	Requirement changed to 40 ppy because pit reuse proves more applicable than expected	Place more plutonium in highly robust containers	Develop lower-MAR manufacturing processes	Move Pu-238 mission out of PF-4
7	Factors increasing demand (requirements) for space	Requirement changed to 125 ppy because pit surveillance reveals unexpected pit problems	Workload for processing drums containing plutonium waste abruptly increases	A new manufacturing layout increases throughput but uses more space	Pit Disassembly and Conversion workload increases
8	Factors reducing demand (requirements) for space	Requirement changed to 40 ppy because plutonium is found to age more slowly than previously thought	Use 2 or 3 shifts per day	A new layout that minimizes space is designed	Some AC equipment is moved from PF-4 to RLUOB

Source: CRS. Green = factors increasing margin; red = factors reducing margin.

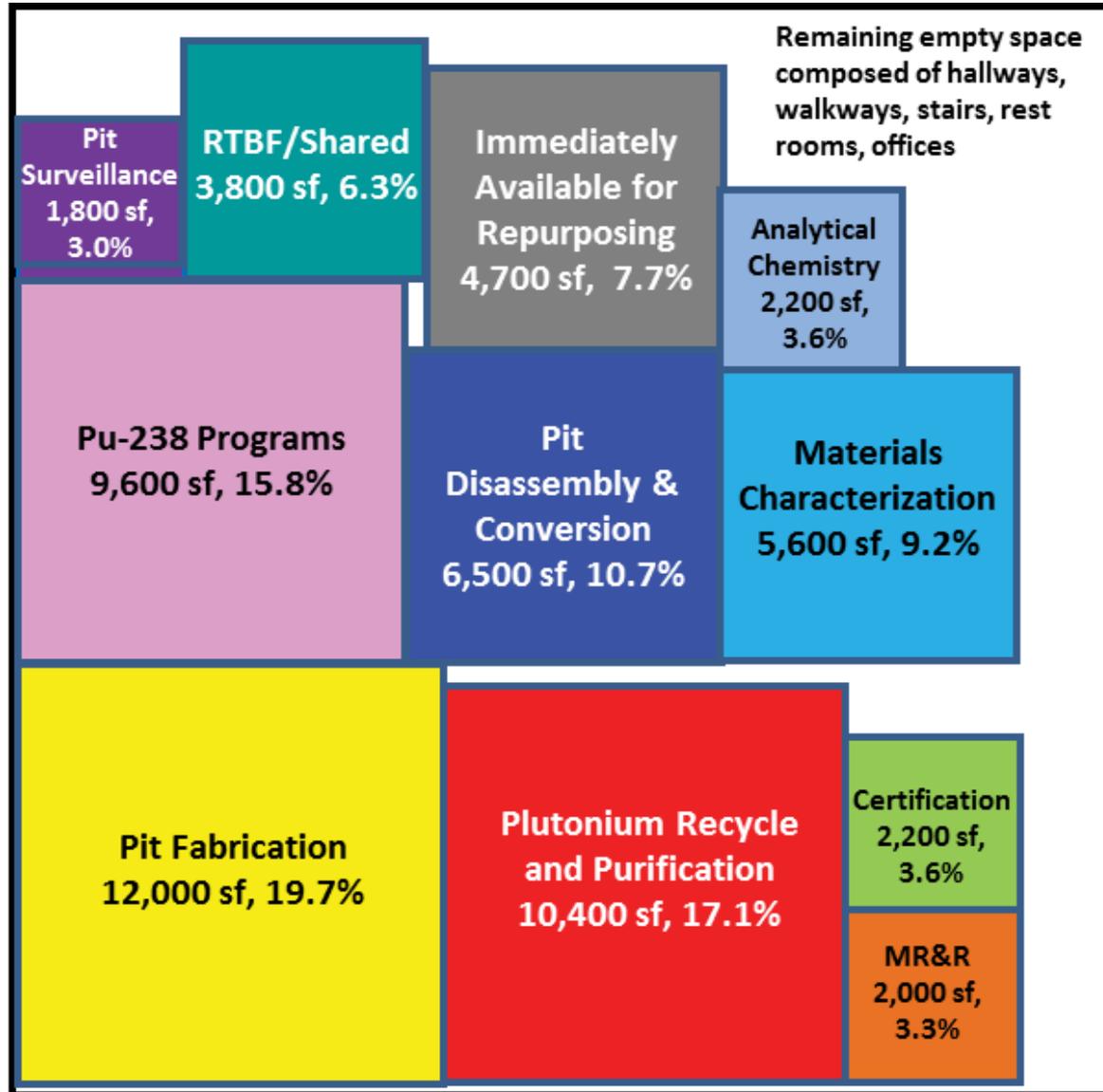
Key Decisions on Margin

- If there is not enough margin for space and MAR for 80 ppy, how can it be provided?
- Once there is enough margin, how can it be maintained over decades despite uncertainties?

Space: Providing and Maintaining Sufficient Margin

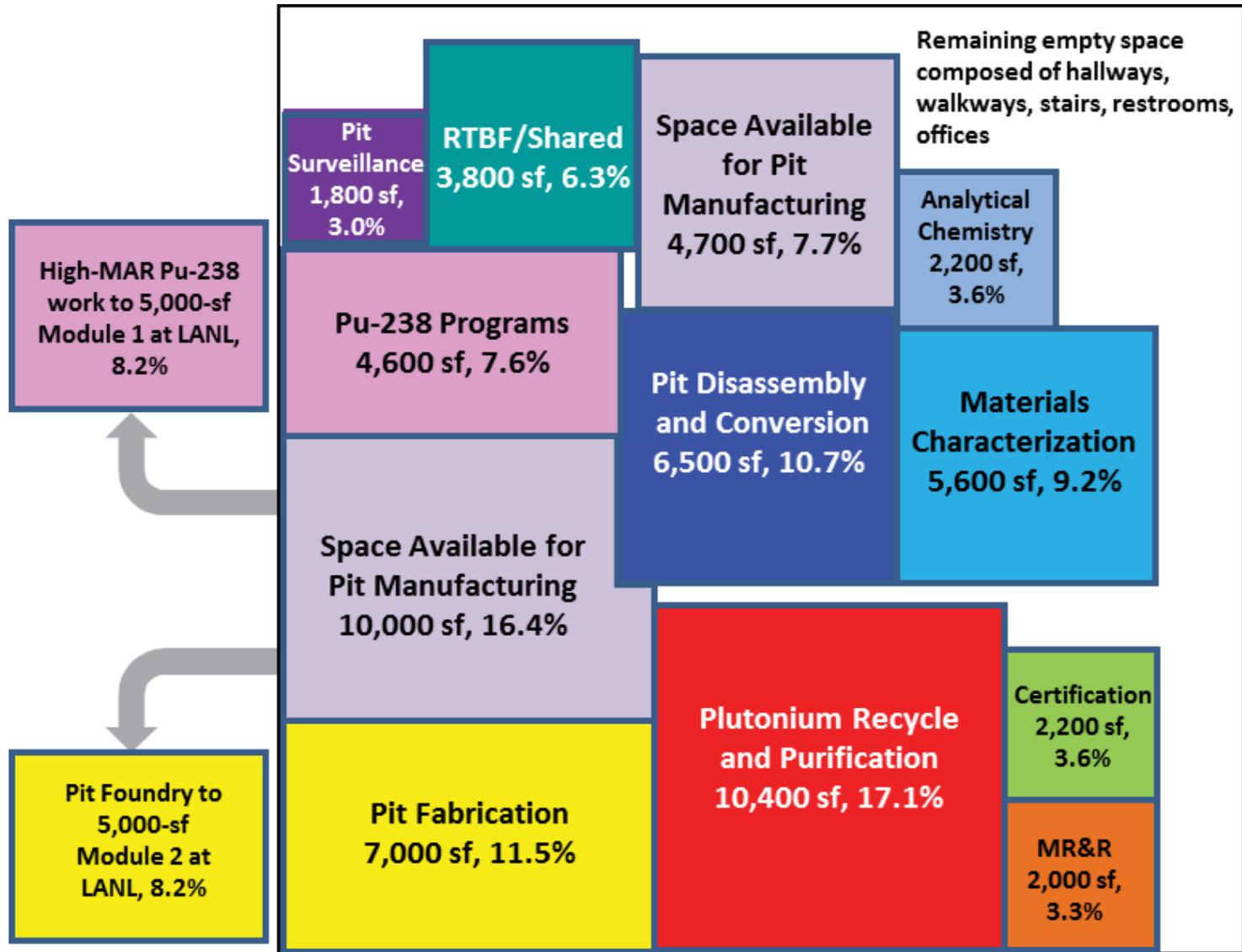
- Focus: PF-4 (Plutonium Facility 4)
 - Main Pu building at Los Alamos National Laboratory (LANL)
 - Only multi-program, multi-function, plutonium processing facility; only building that can currently make pits
- Various construction/non-construction options
 - Implement some promptly, hold others in reserve
 - Ability to maintain margin provides confidence in capacity
 - May assess margin annually

PF-4 Space Allocation as of Early 2012



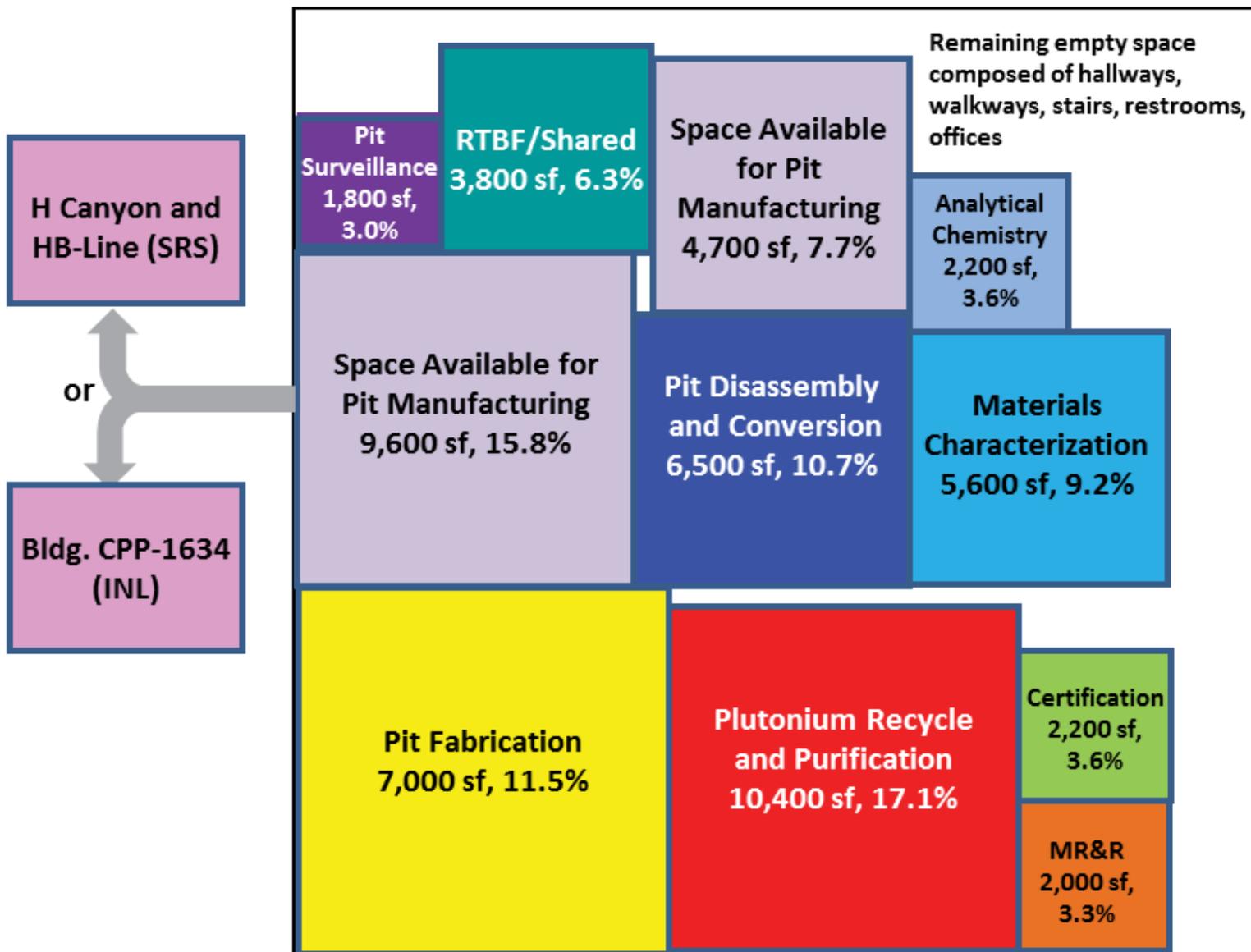
Source: Los Alamos National Laboratory. The blocks in this diagram represent space allocations to scale, but do not show the physical location of each activity within PF-4.

Releasing Space in PF-4 with Two Modules



Source: Base graphic, Los Alamos National Laboratory, modifications by CRS. The blocks in this diagram represent space allocations to scale, but do not show the physical location of each activity within PF-4.

Releasing Space in PF-4 by Moving Pu-238 Offsite



Source: Base graphic, Los Alamos National Laboratory, modifications by CRS. The blocks in this diagram represent space allocations to scale, but do not show the physical location of each activity within PF-4.

Increasing Space Margin in PF-4 for Mfg without Major Construction (Examples)

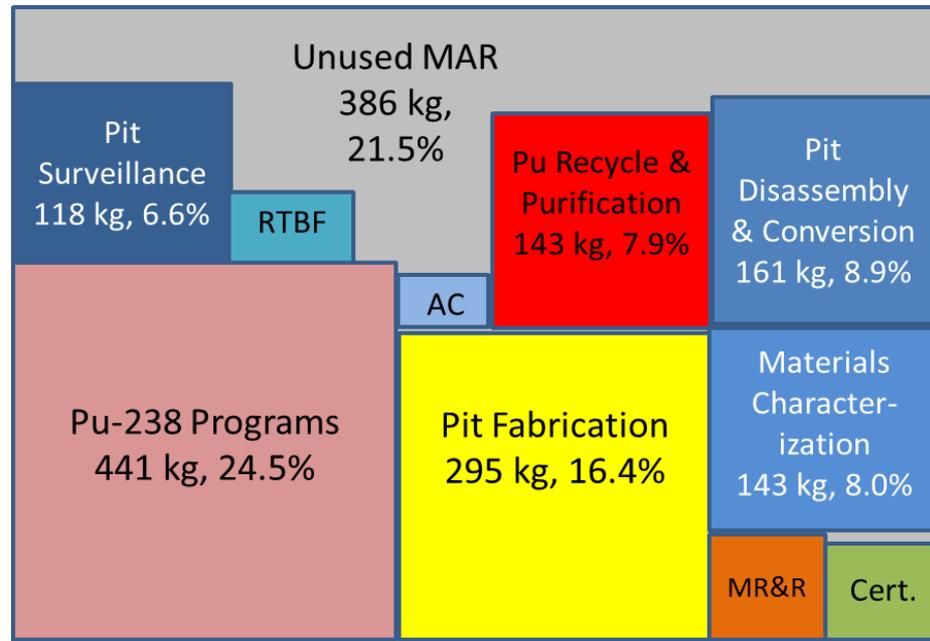
- Use additive mfg. to fabricate segmented crucibles for electrorefining Pu
- Repurpose unused or lower-priority space
 - E.g., remove unused gloveboxes
- Make better use of basement
- Use 2 or 3 shifts per day
- Use CaCl, not NaCl-KCl, in electrorefining Pu

MAR: Providing and Maintaining Sufficient Margin

- Focus: PF-4
- Various construction/non-construction options

PF-4 MAR Usage by Program on 2/27/2013

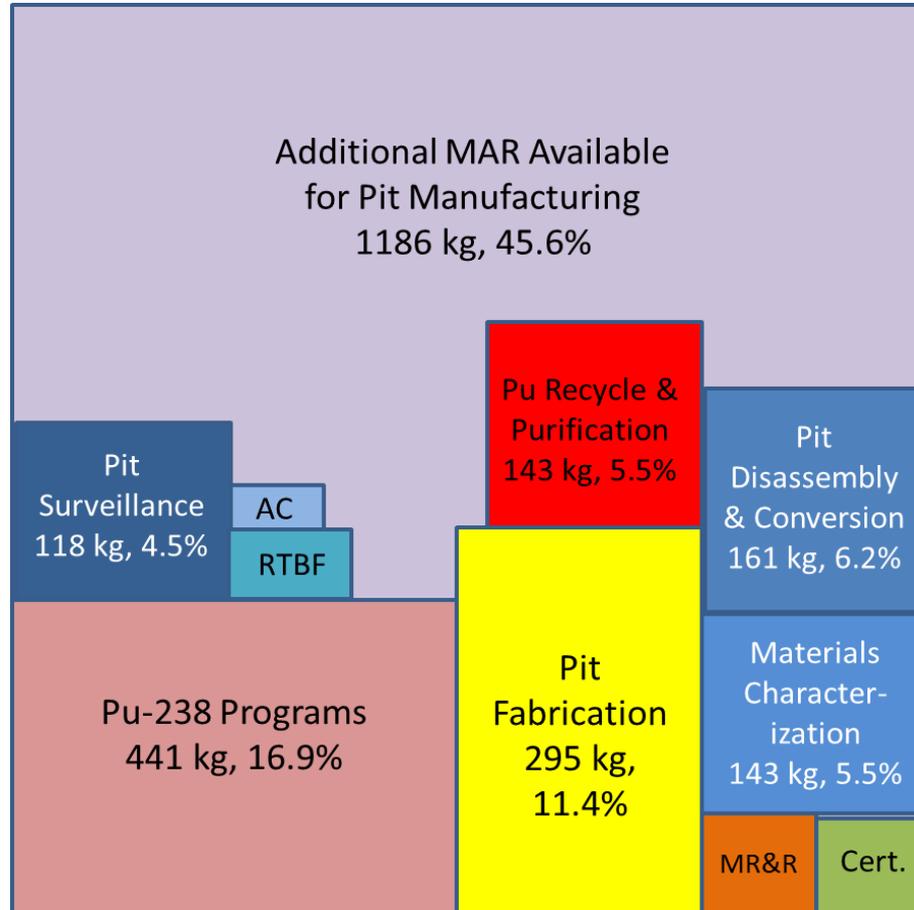
Units in this graphic are kilograms of plutonium, not area
MAR allowance for this configuration is 1,800 kg of plutonium



Source: Los Alamos National Laboratory. The blocks in this diagram represent MAR allocations to scale, but do not show the physical location of each activity within PF-4. MAR allowance for this and the next three slides is for the main laboratory floor of PF-4.

PF-4 MAR with Seismic Upgrades

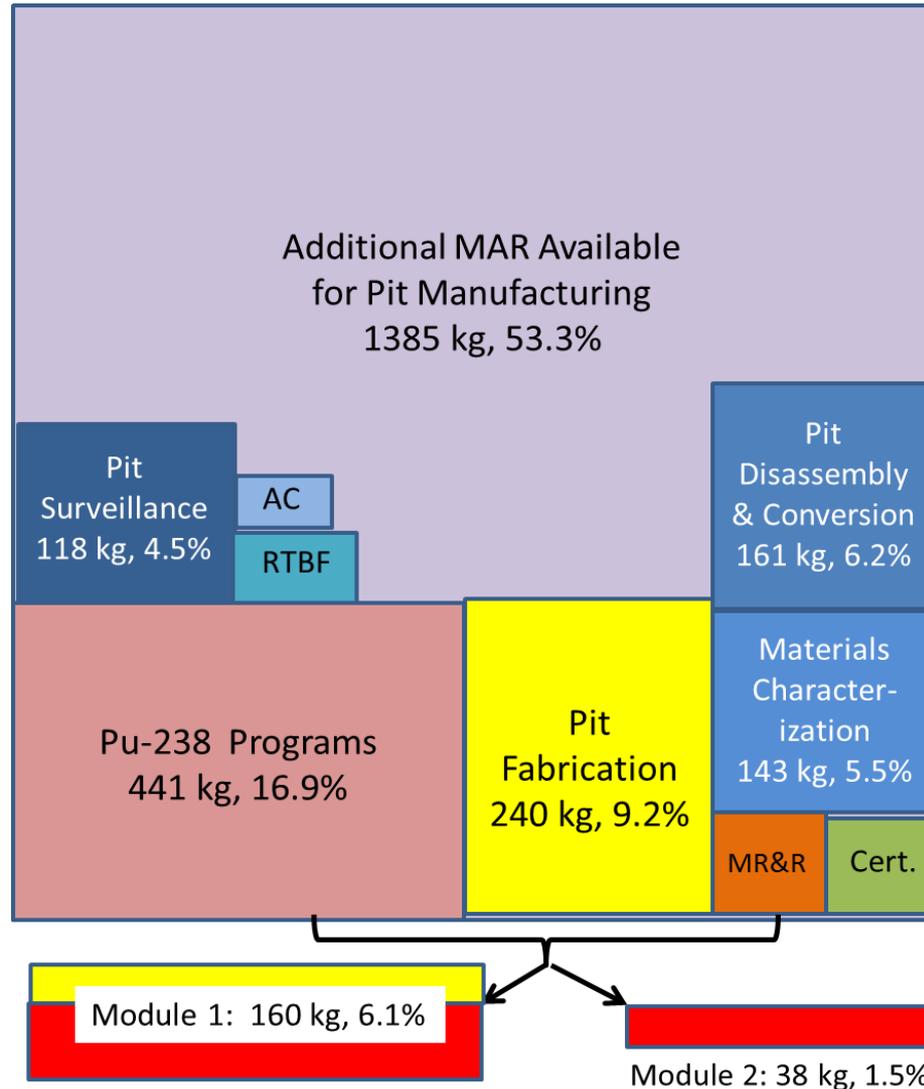
Units in this graphic are kilograms of plutonium, not area
MAR allowance for this configuration is 2,600 kg of plutonium



Source: Data provided by Los Alamos National Laboratory, graphic by CRS. MAR available for pit manufacturing in this and the next two slides has increased because seismic upgrades are assumed to permit a substantial increase (here, 44%) in PF-4 MAR. The blocks in this diagram represent MAR allocations to scale, but do not show the physical location of each activity within PF-4.

PF-4 MAR with Two Modules

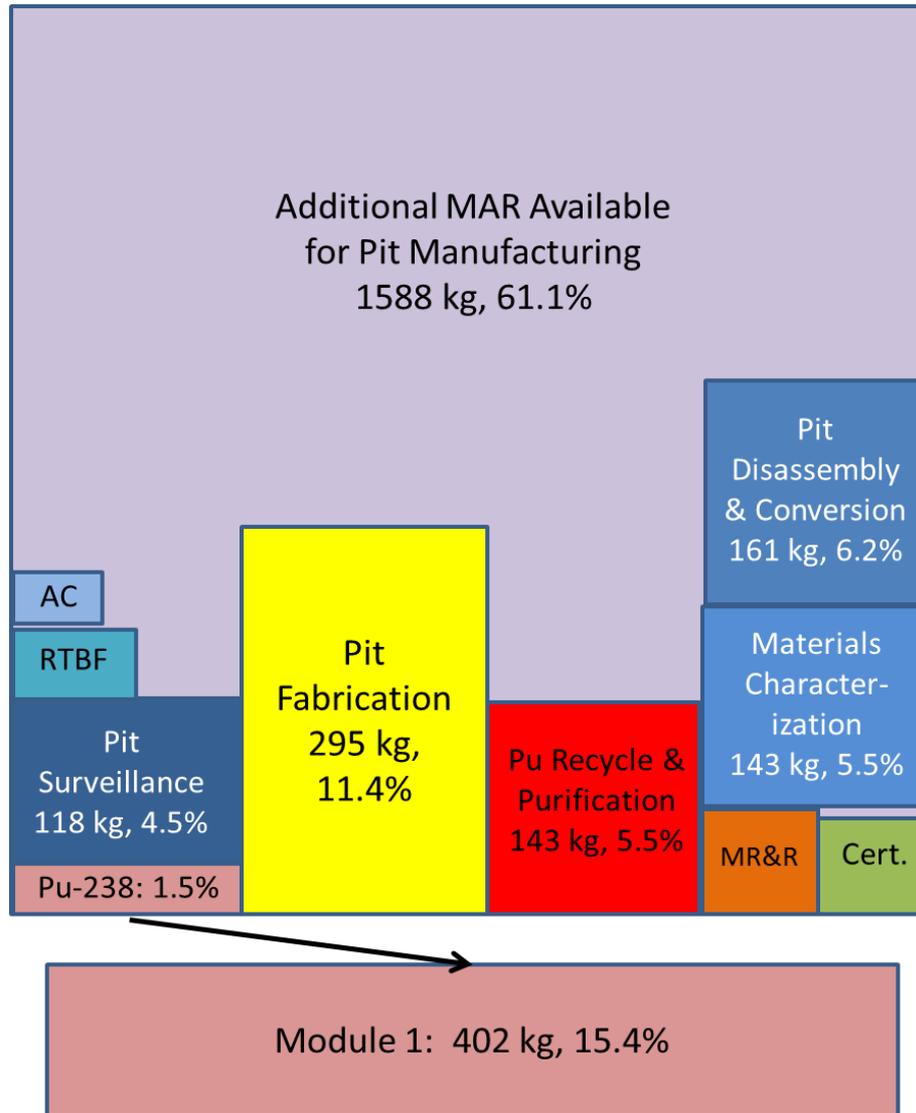
Units in this graphic are kilograms of plutonium, not area
MAR allowance for PF-4 for this configuration is 2,600 kg of plutonium



Source: Data provided by Los Alamos National Laboratory, graphic by CRS. Module 1, molten Pu operations; Module 2, aqueous (acid) processing of Pu. The blocks in this diagram represent MAR allocations to scale, but do not show the physical location of each activity within PF-4.

PF-4 MAR with One Module

Units in this graphic are kilograms of plutonium, not area
MAR allowance for PF-4 for this configuration is 2,600 kg of plutonium



Source: Data provided by Los Alamos National Laboratory, by CRS. The blocks in this diagram represent MAR allocations to scale, but do not show the physical location of each activity within PF-4.

Increasing MAR Margin in PF-4 without Major Construction (Examples)

- Strengthen PF-4 seismically

- Wrap columns; shear walls; reinforce ceiling; drag strut
- These reduce risk of PF-4 collapse in design basis earthquake



Photo: Google Maps. Photo shows PF-4 roof with drag strut circled.

- Reduce risk that PF-4 collapse releases Pu

- Install rugged containers in production areas
- Anchor gloveboxes more strongly to floor
- Remove tons of combustible material from PF-4

Increase MAR by Avoiding Hyper-conservative Calculations of Dose

- MAR permitted for each building depends on calculation of dose
- Ten-factor equation links MAR to dose

Dose as Function of MAR for PF-4 Using Conservative and Hyperconservative Assumptions

Factor	Conservative	Hyperconservative
MAR, g Pu-239 equiv (Pu-239E)	2.60E+06	2.60E+06
Damage Ratio, DR	0.1	1
Airborne Release Fraction, ARF	0.0003	0.002
Respirable Fraction, RF	0.3	0.5
Leak-Path Factor	0.1	1
"Chi over Q," X/Q (s/m ³)	1.00E-06	8.77E-05
Breathing Rate, BR (m ³ /s)	0.00033	0.00033
Specific Activity, SA (Ci/g) for Pu-239E	0.0622	0.0622
Dose Conversion Factor, DCF (rem/Ci)	5.92E+07	5.92E+07
Dose (rem)	.00474	166
Dose guideline (rem) per DOE regs	5-25	5-25

Factors are based on DOE rules except Chi over Q, which is specific to TA-55 (main plutonium area at LANL). Chi over Q includes such factors as distance, wind speed, wind direction, and deposition rate. ARF is specific to material form and accident scenario.

Increase MAR by Avoiding Hyper-conservative Calculations of Dose

- “When several input parameters are taken at their bounding values, the obtained result dwarfs the derived 95th percentile of the output by orders of magnitude.” (K. Jamali)
- Using conservative instead of hyperconservative assumptions reduces dose by 35,000x

Wrapup

- Many paths toward 80 ppy
- Can't know which ones provide enough margin without data on MAR and space requirements
 - No changes may be needed, or
 - Non-construction options may suffice, or
 - Minor construction may suffice, or
 - Major construction may be required
 - Can't tell if 0, 1, 2, or 3 modules would be necessary
 - Can't tell if 0, 1, 2, or 3 modules would be sufficient