ROWAN TECHNOLOGY GROUP
Linking Global Technologies with Markets

Implementation Assessment – Beyond the CBA
Evaluating Technology Gaps, Costs, and Life-Cycle Benefits

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HARD CHROME ALTERNATIVES TEAM

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Why do people do Cost Benefit Analysis and Environmental Assessment?

- To understand whether or not it makes financial and environmental sense to invest in a new technology
  - Implementation Assessment can be a powerful tool to understand the technical and financial implications
- As a sales tool to show how much money it will save and how much hazardous material it will remove
  - Implementation Assessment gives a full accounting of potential benefits
  - But remember it also gives a full accounting of up-front costs
- Because Chuck Pellerin told you to

What goes into the typical CBA and Environmental Assessment?

For analysis of a process or material change

- Detailed evaluation of relative materials costs
- Detailed evaluation of relative processing cost
- Detailed evaluation of ESOH costs
- Some accounting for expected savings from improved performance (e.g. longer repair cycle)
- Environmental impact of changes from reduction in use and discharge of hazardous materials

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What does the typical analysis leave out?

- Pretty much all the big stuff!
  - Cost of developing the technology
  - Full cost of qualifying it and putting it into production
  - All the savings derived from performance improvements
  - Changes in (reduction of!) service failures
    - With all collateral costs involved
  - Reduction of component condemnation
    - With all collateral costs involved

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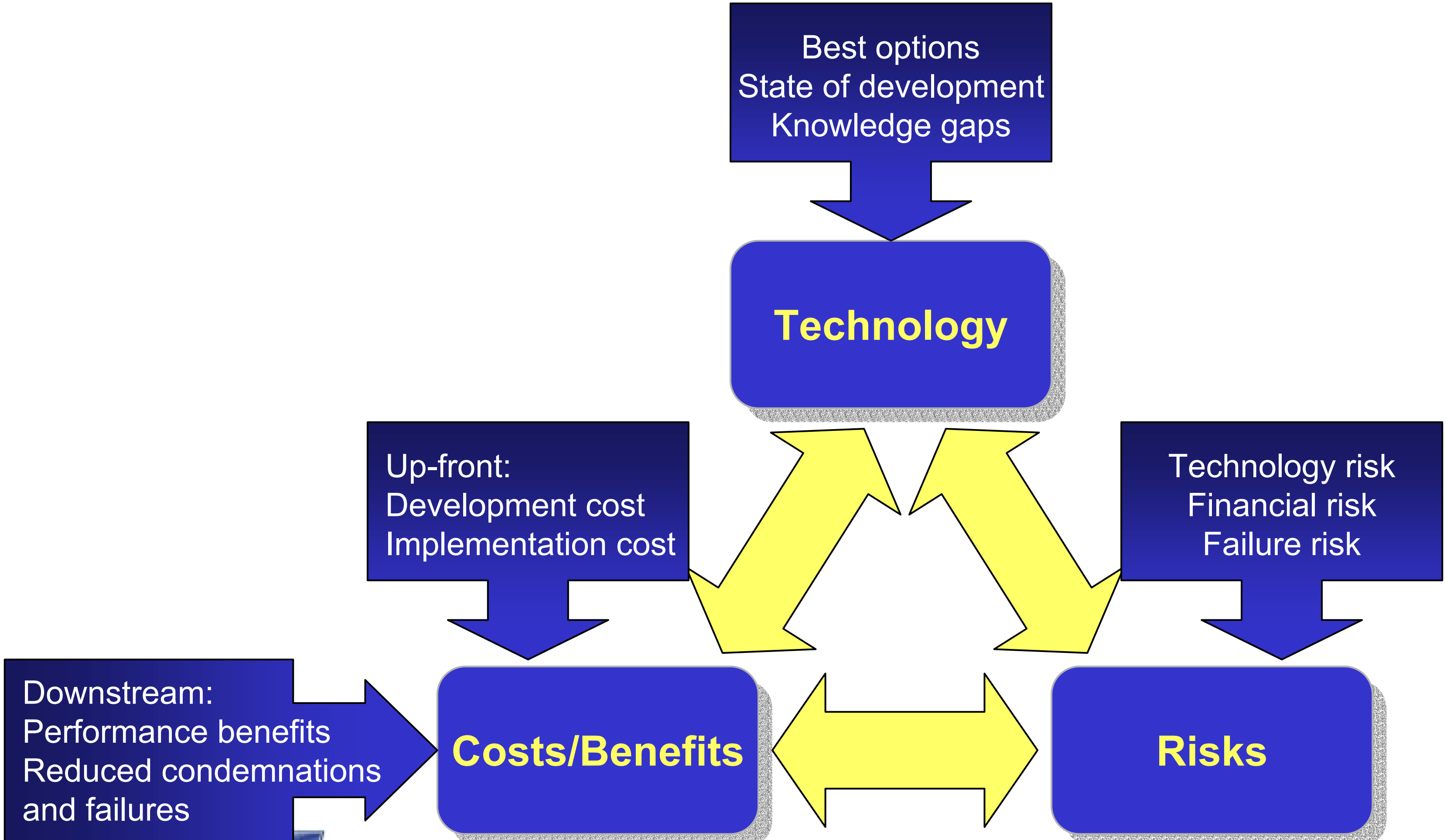
Putting it all together



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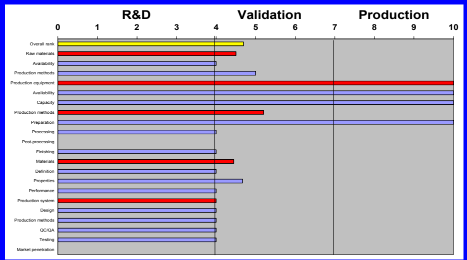
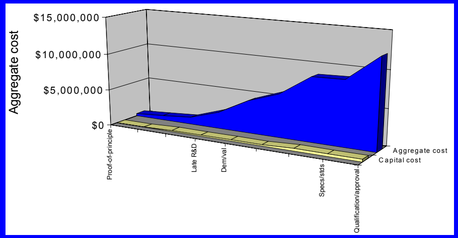
Implementation Assessment structure

Technology



Degree of development
Technology gaps
Technology risk

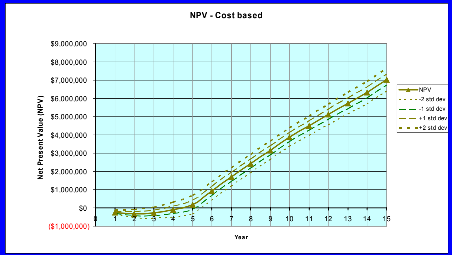
Cost & Risk



R&D costs
Implementation costs
Environmental costs
Disposal costs
Risk reduction

Performance savings
Cost avoidance
ESOH/Hazmat reduction

Benefits



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Technology Analysis

- What technologies are available or in development?
  - How closely do they meet primary requirements?
  - Realism – where are they in the “Lab to Life Line”
    - Gleam in the eye
    - Well developed
    - Full production
  - How well do they fit with the production environment?
  - Do they offer potential improvements/life cycle cost savings over the existing technology?
  - How environmentally friendly are they?

LINKING GLOBAL TECHNOLOGIES WITH MARKETS

Final Report

Chrome Replacements
for
Internals and Small Parts

Contract #: F33615-95-C5615
Subcontract #: 4400002135
Project #: 01-0824-38-5025-000

Principal Investigator: Keith O. Legg

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Technology Status Summary

- Semi-quantitative method developed under JSF funding for analyzing technology options
- Consider the production process
  - Assign each production requirement a rank based on standard production-readiness criteria
  - Graphical output of results quickly shows technology status and critical gaps

Raw materials

Production equipment

Production methods

Materials

Properties
Performance

Production system

Market penetration

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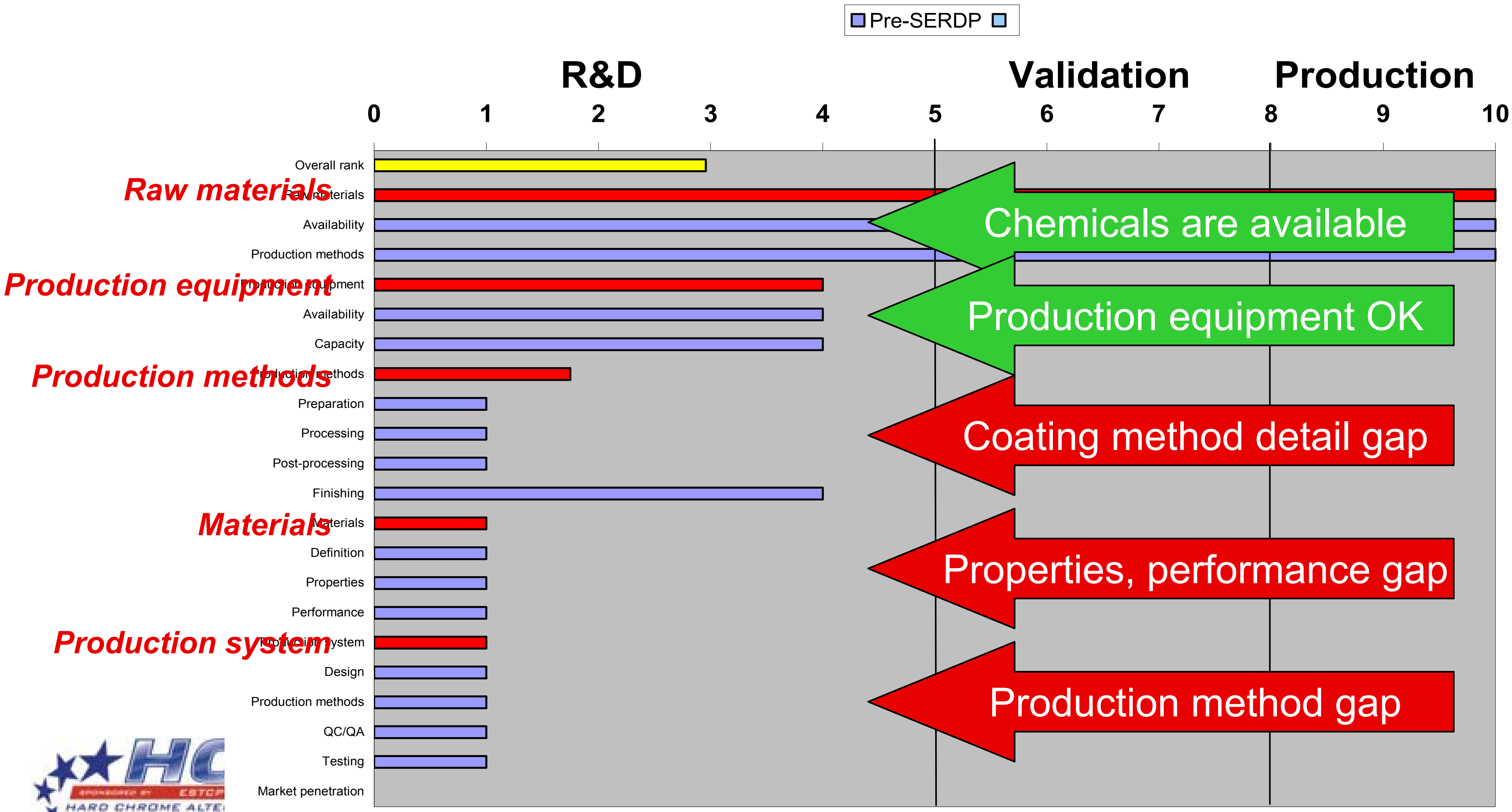
Technology Status Summary criteria

Rank	Description	Ranking criteria
0	Not possible with reasonable manufacturing approach	Fundamental reason why it cannot be done
1	Initial concept	Initial concept with backup reasoning
2	Early R&D - basic methods and properties	Demonstrated lab production, initial data
3	Proof-of-principle	Demonstrated lab production - equipment design viable, performance requirements appear attainable
4	Late R&D	Demonstrated lab scale; acceptable performance in most critical areas; no show stoppers
5	Acceptable performance demonstrated	Acceptable performance demonstrated in all critical areas using lab-scale equipment
6	Production demonstrated/ validated	Demo'd full scale; full data sets obtained; acceptable performance in all critical areas
7	Specs, standards developed	General specs or standards issued, or commercial specs exist
8	Qualification/ approval obtained	Approved for production
9	Early commercial	Commercial production of a few (<~20) different items
10	Market acceptance	>10% of general market, or well-defined niche

Example – Technology Status Summary for nanophase electroplates prior to SERDP Project #1152

Nanophase Co alloy electroplate



After completion of SERDP Project #1152

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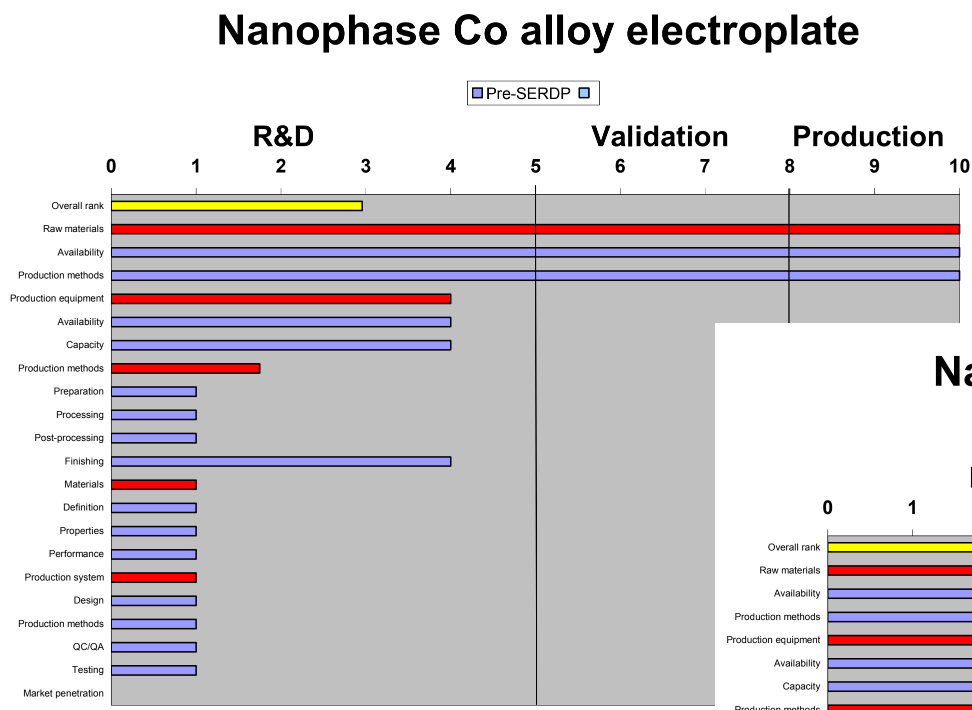
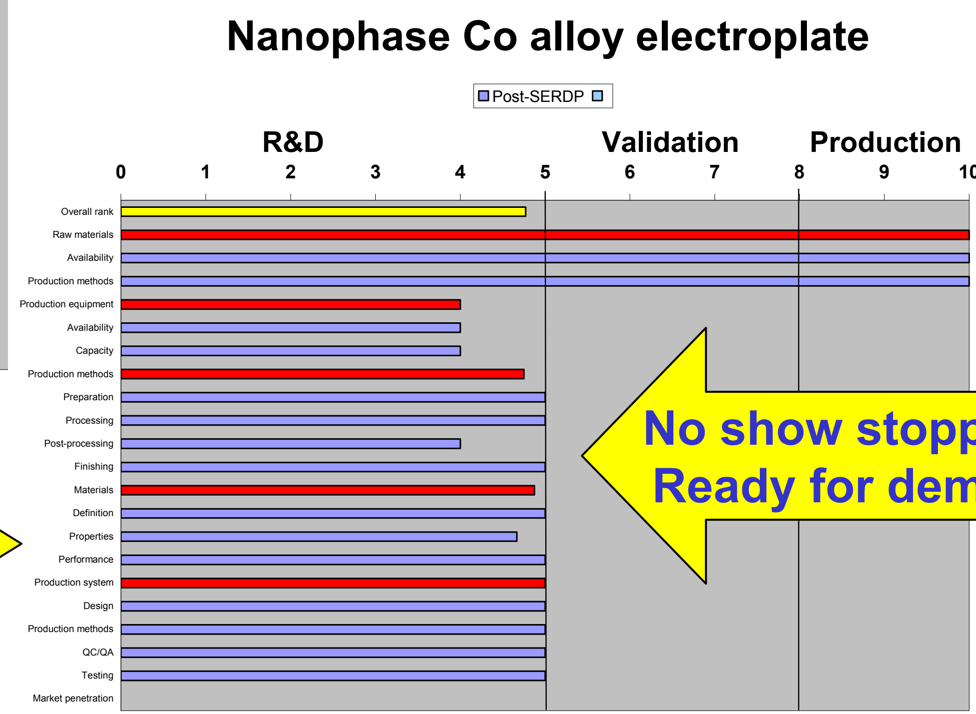


Pre-SERDP



Post SERDP

No show stoppers!
Ready for dem/val

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Technology Risks – Gap Analysis

- Technology Status Summary + experience + analysis of the engineering field
  - Where are the technology gaps?
    - Are they problems of engineering or fundamental science?
  - What is the likelihood of serious or insurmountable deficiencies in any critical area?
    - Are some gaps particularly large or difficult?
    - Do we have sufficient resources to bridge the gaps?
    - Are competing technologies likely to come to production first?
  - Implementation Assessment provides a picture of the overall technology readiness and risks

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Financial assessment

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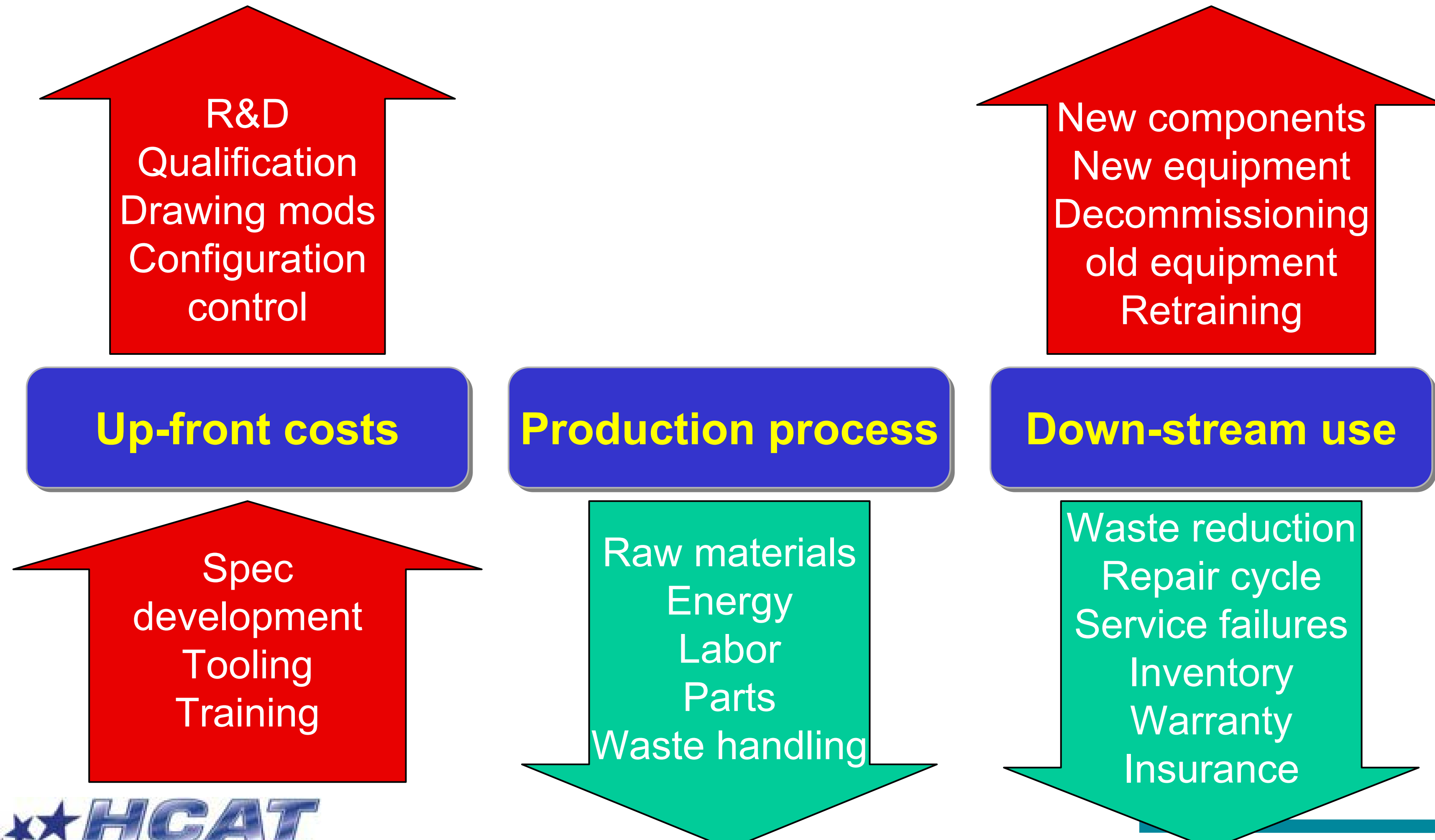
Cost Benefit Analysis – the C-MAT tool

- Calculation for Material Alternative Technologies
- Decision Tool funded by SERDP for Stainless Steel Landing Gear program (Project # PP-1224)
  - Designed primarily for analysis of materials and process substitutions
  - Very extensive inclusion of up-front costs and down-stream benefits
  - Inclusion of data accuracy estimates to assess financial risk
  - Standard financial measures (Cash Flow, NPV, ROI, Payback Period)
- C-MAT does not just measure the cost/benefit of using the new technology vs the cost of using the old
  - It measures the full costs and benefits of moving to the new technology vs the costs and benefits of continuing to use the old

Costs and Benefits



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The critical question

Why do you want to change?

- The real answer is rarely “Because Cr/Cd/name-your-poison is bad and we want to quit using it”
- It is usually an engineering, cost, worker safety, or availability issue:
  - Ogden would like to replace Cd-plated landing gear because of the frequent corrosion and stress corrosion cracking failures associated with Cd-plated 300M
    - The primary driver is service failure cost, with all its collateral damage costs and risks to personnel
  - NADEP Cherry Point would like to replace chrome-plated prop hub parts with HVOF-sprayed parts because it will extend the service life of parts that are no longer made
    - The primary driver is avoiding part condemnation and ensuring readiness – keeping planes flying

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Scenarios

- The heart of the C-MAT approach is the Scenario
  - The Scenario models the way the new technology is to be phased in and used, or how the old is to be phased out
  - Can work with Cash Flow (mostly OEMs) or Cost (mostly DoD O&R)

Cash flow difference = **Cash flow of phasing out existing technology** + **Cash flow of phasing in new technology** - **Cash flow of continuing to use existing technology**

  - New Scenarios can easily be built from old ones to generate What-Ifs
    - Web-enabled reports permit interactive What-ifs via our website at www.materialoptions.com

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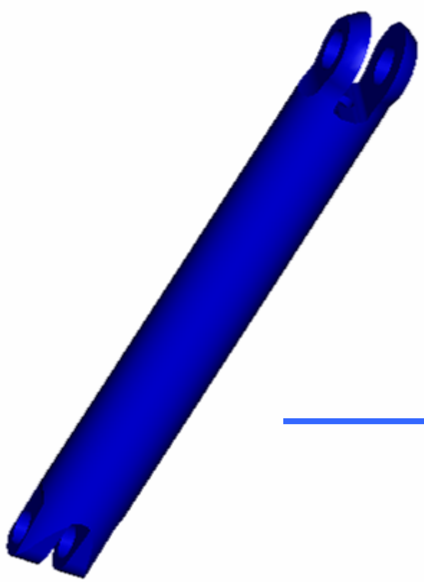
C-MAT example – KC-135 drag brace strut



KC-135R is re-engined for more lift and better fuel performance.
Non-R (i.e. KC-135) models are older and use 4330 drag brace strut.
Problem is corrosion inside hollow strut.

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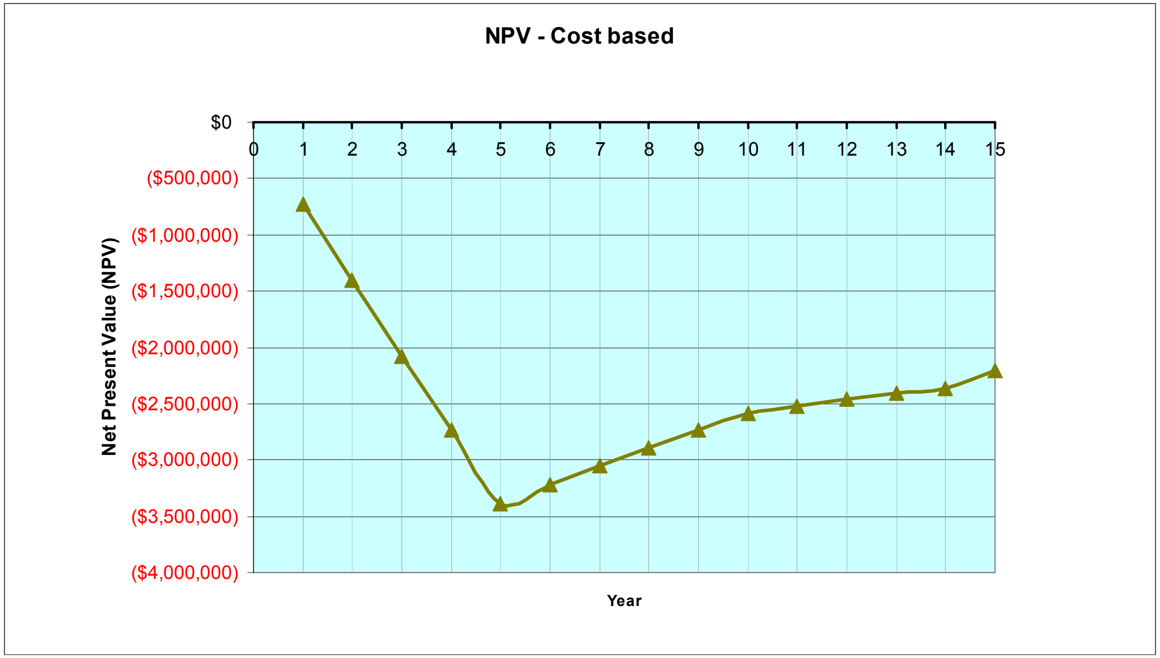
A simple cost comparison

Initial calculation for stainless part based solely on replacement cost vs overhaul cost

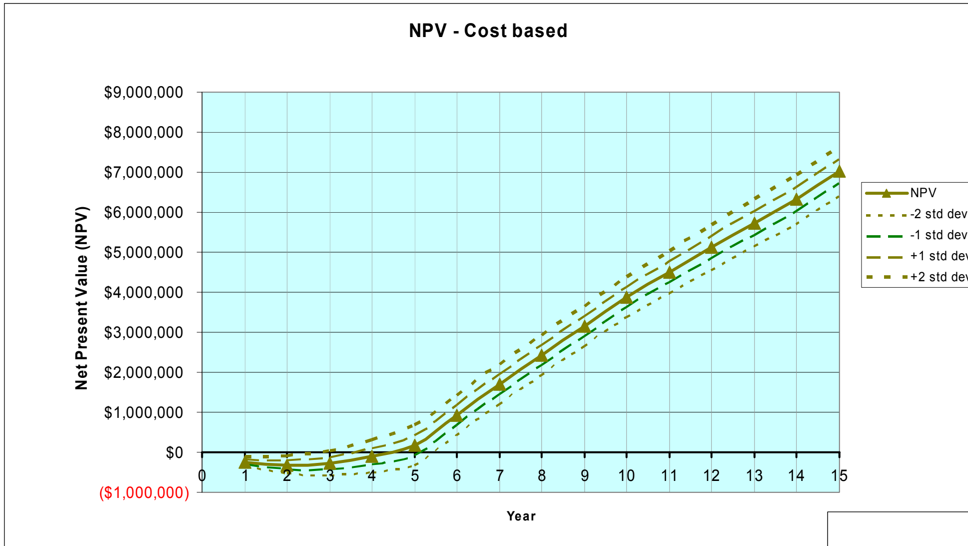


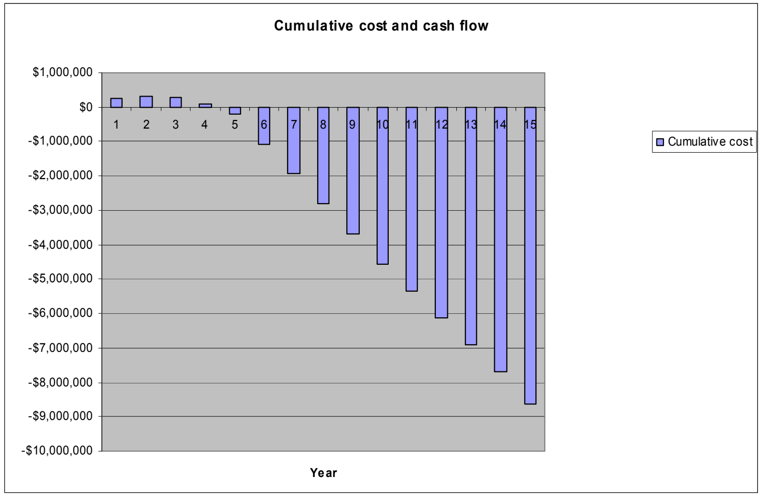
- NPV is value today of an income stream (savings)
- NPV depends on how long you take it over
  - The longer you go the more the savings build
- At 15 years still has large negative Net Present Value
- Payback period = 27 years
  - We'll have bright new B767s long before then (maybe – or maybe not)

But where are the really big savings?

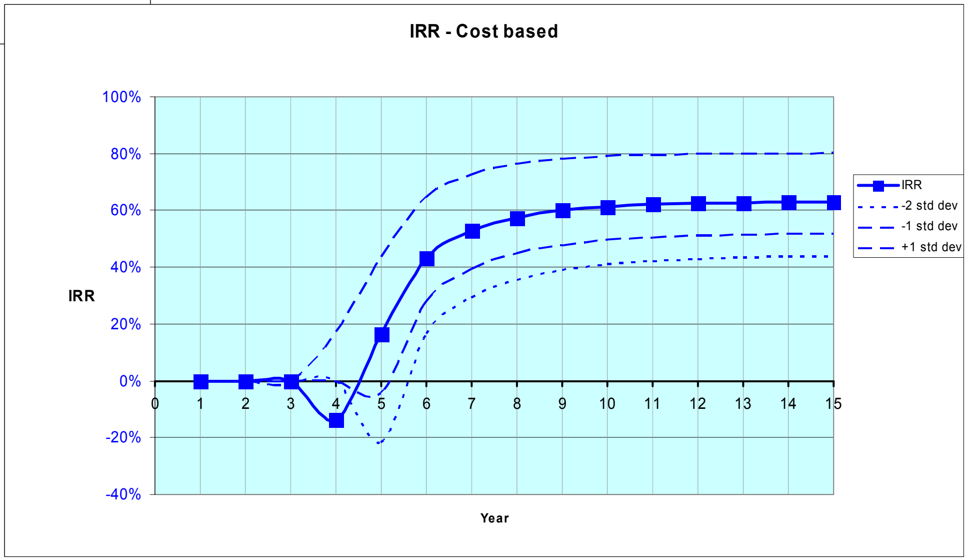
- Again, we ask the critical question
  - **"Why do you want to make this change?"**
    - Answer: "Because most of our problems are corrosion and SCC, which leads to unpredictable service failures."
    - This component is prone to ID corrosion and very difficult to inspect
      - Only 1 major failure past 10 years – Class B (>$500,000 collateral damage)
      - But concern that we are sitting on a time bomb that will lead to more unpredictable major failures as system ages
  - So, S-53 high strength stainless steel has 2 major expected cost and risk avoidance impacts:
    - Reduction or elimination of corrosion-related condemnation, so greatly reduced new component purchase downstream
    - Reduction or elimination of service failures related to corrosion and SCC and hydrogen embrittlement (all difficult or impossible to detect)
      - Eliminates ongoing corrosion failures and consequent need to condemn parts
      - Eliminates major failures and their collateral damage
  - Therefore the Scenarios should include performance impacts on the cost of service failure
    - One can only come up with estimates based on historical costs and reasonable estimates for future failures (risk)

Effect of including failure costs and more reasonable component cost





- Payback period 3 - 6 yrs
- NPV is $6.5 - $7.5 million over 15 years on non-R KC-135 alone when we use a more reasonable component cost and include the likely cost of service failure



What if……….?

- The Scenario was built on the assumption that we would replace each old drag brace strut at overhaul with a brand new stainless strut
- But what if
  - We started seeing lots of SCC failures and wanted to replace in the field as fast as possible?
  - We just replaced them whenever they failed or had to be condemned?
  - The Air Force decided to scrap the KC-135 fleet over the next 10 years?
  - Combat operations mean they start seeing a lot more corrosion?
- Each new Scenario can be quickly built from the original Scenarios to provide a means of quickly evaluating the impact of different decisions

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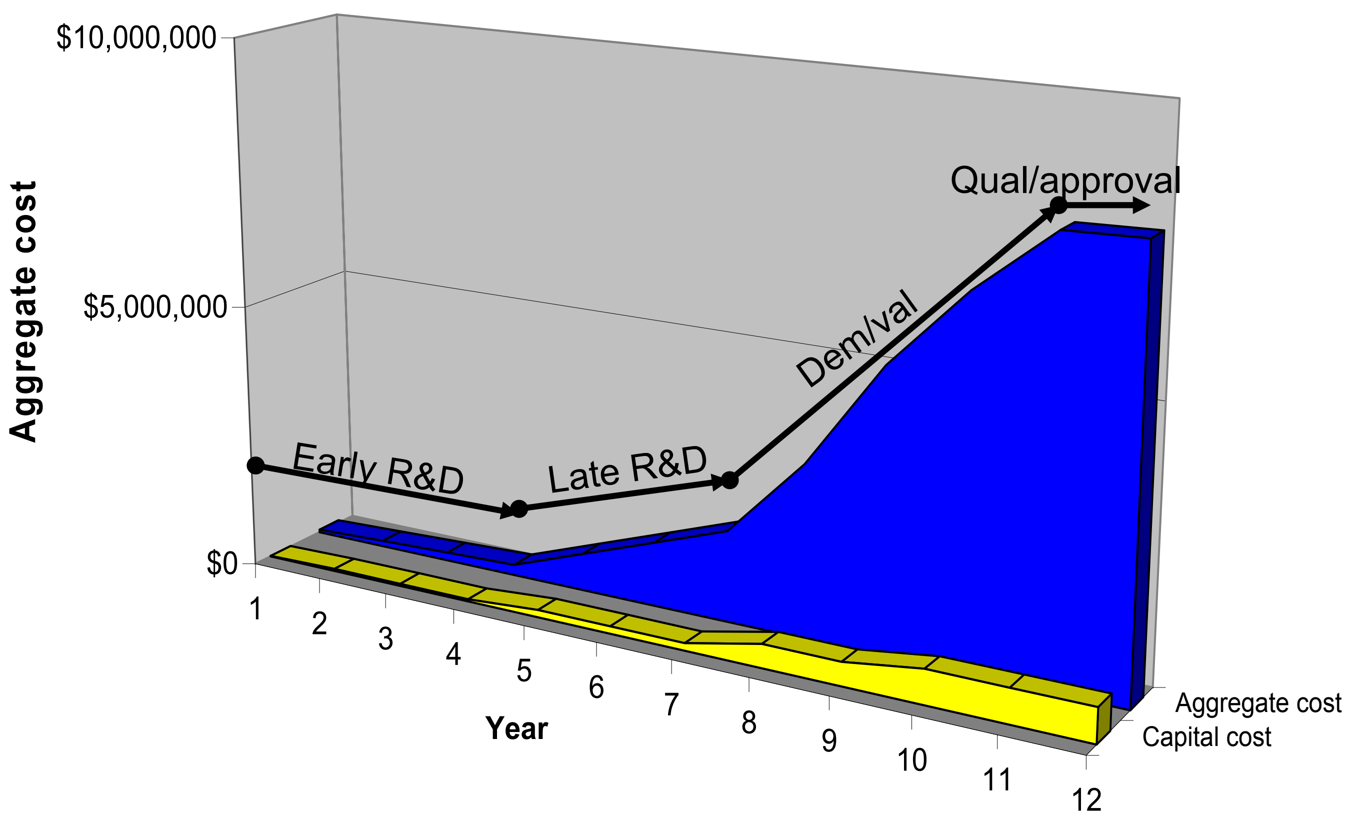
Assessing costs and risks at different stages of development



- Cost estimates from current stage of development
- Based on Technology Status Summary + costs of development, testing, validation, etc.
- Financial risk combines aggregate cost with technology gaps

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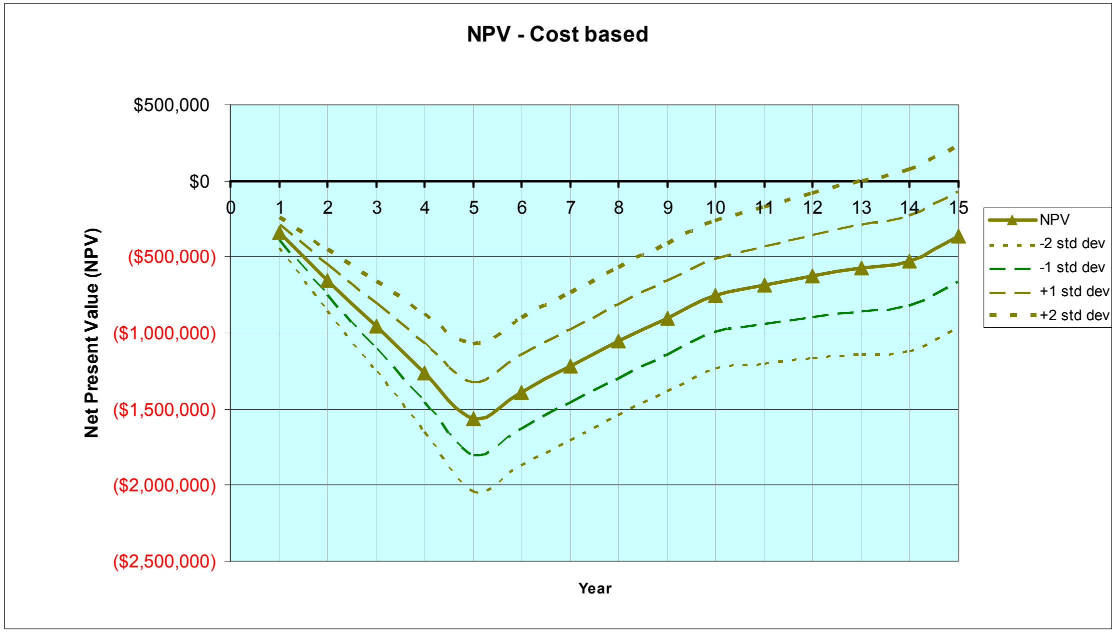
Financial risk



- Uncertainties in quantities and costs give spread in total investment needed and payback period
- We can calculate the probability of
  - never getting a payback
  - having to put in more money than expected

Summary

- No matter what the stage of development an Implementation Assessment can give a picture of the total cost and technical/financial risk of replacing an old technology with a new one
- Technology status and development cost can be combined with the cost and risk of different Implementation Scenarios to decide on the best approach, for example
  - Lowest cost
  - Lowest risk
  - Fastest implementation