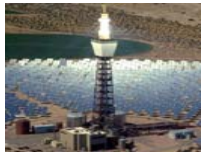
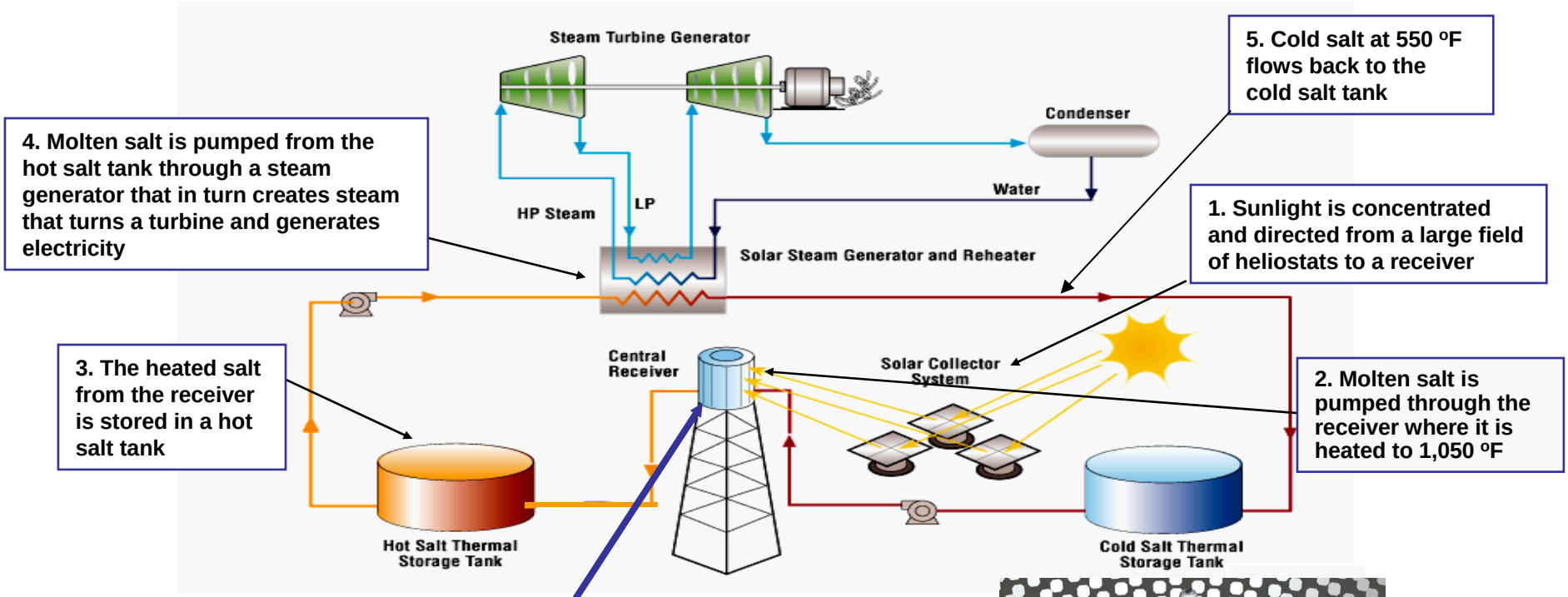
Pratt & Whitney Rocketdyne Receiver Overview

Kris Miner, Project Team Lead

Program Review Meeting with DOE

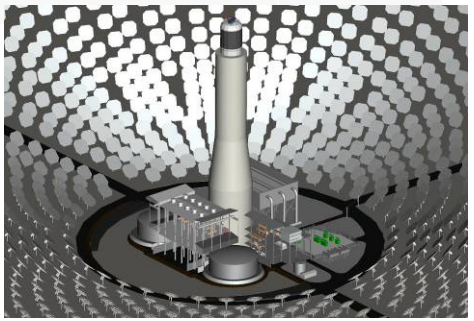
Solar Power Tower Description





Central Receiver

Power Tower



Future CSP Plant

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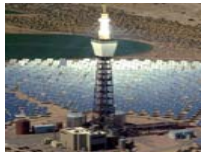
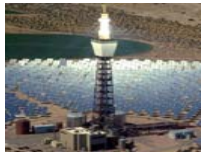
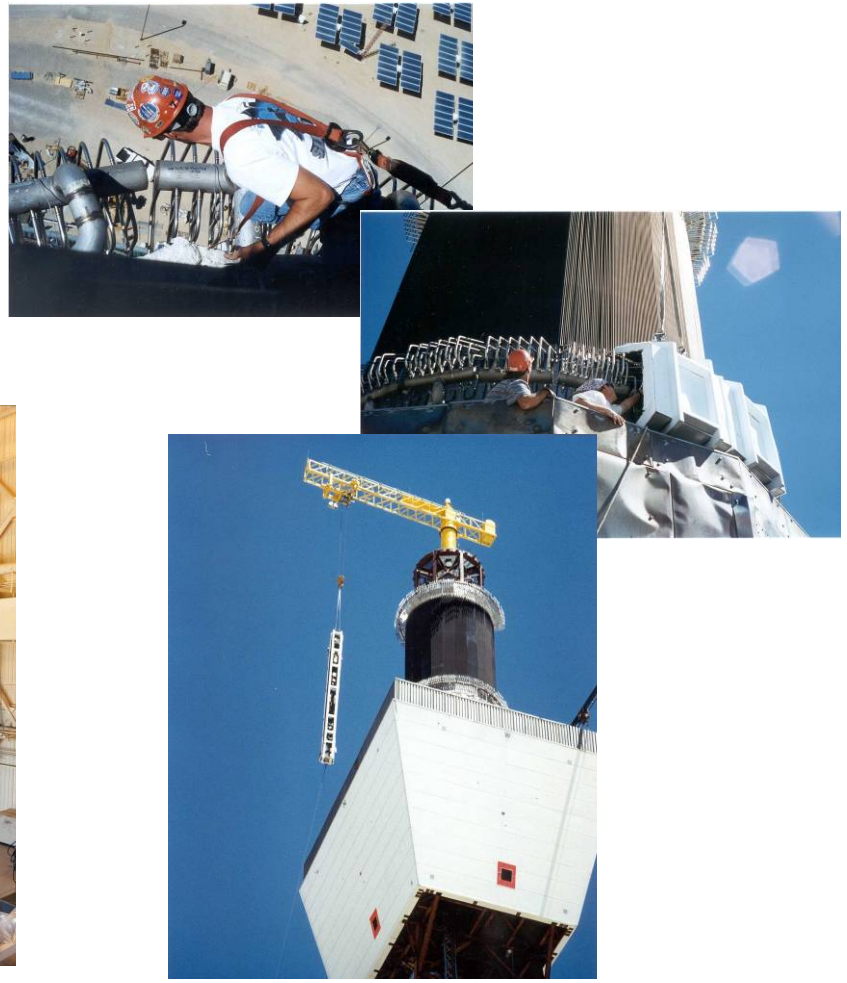
Project Objectives



- The key technical risk with building molten salt solar power towers is building larger receivers
  - This project is helping to resolve that risk by gaining experience with the design, fabrication, and testing of large receivers
- Validate manufacturability of large scale molten salt receiver panel
- Confirm operation in prototypic solar flux
- Goal of reducing LCOE of solar power plant

Receiver Panels are the Key Component





Fabrication at
Pratt & Whitney Rocketdyne

Installation at Barstow, Calif.

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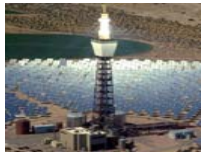
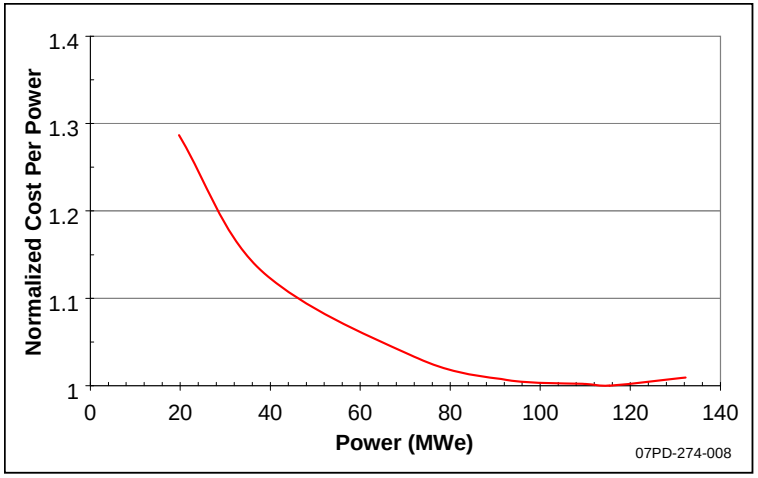
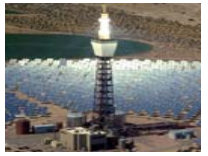
Receiver – Relationship to Solar Program Goals



"…to make CSP cost competitive by demonstrating larger receiver design, enabling economy of plant scale to reduce LCOE. A power tower of 100 MWe or more can achieve under 7 cents/kWh with storage (12-17 hours) by 2020."

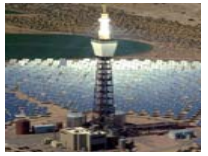


Project Description

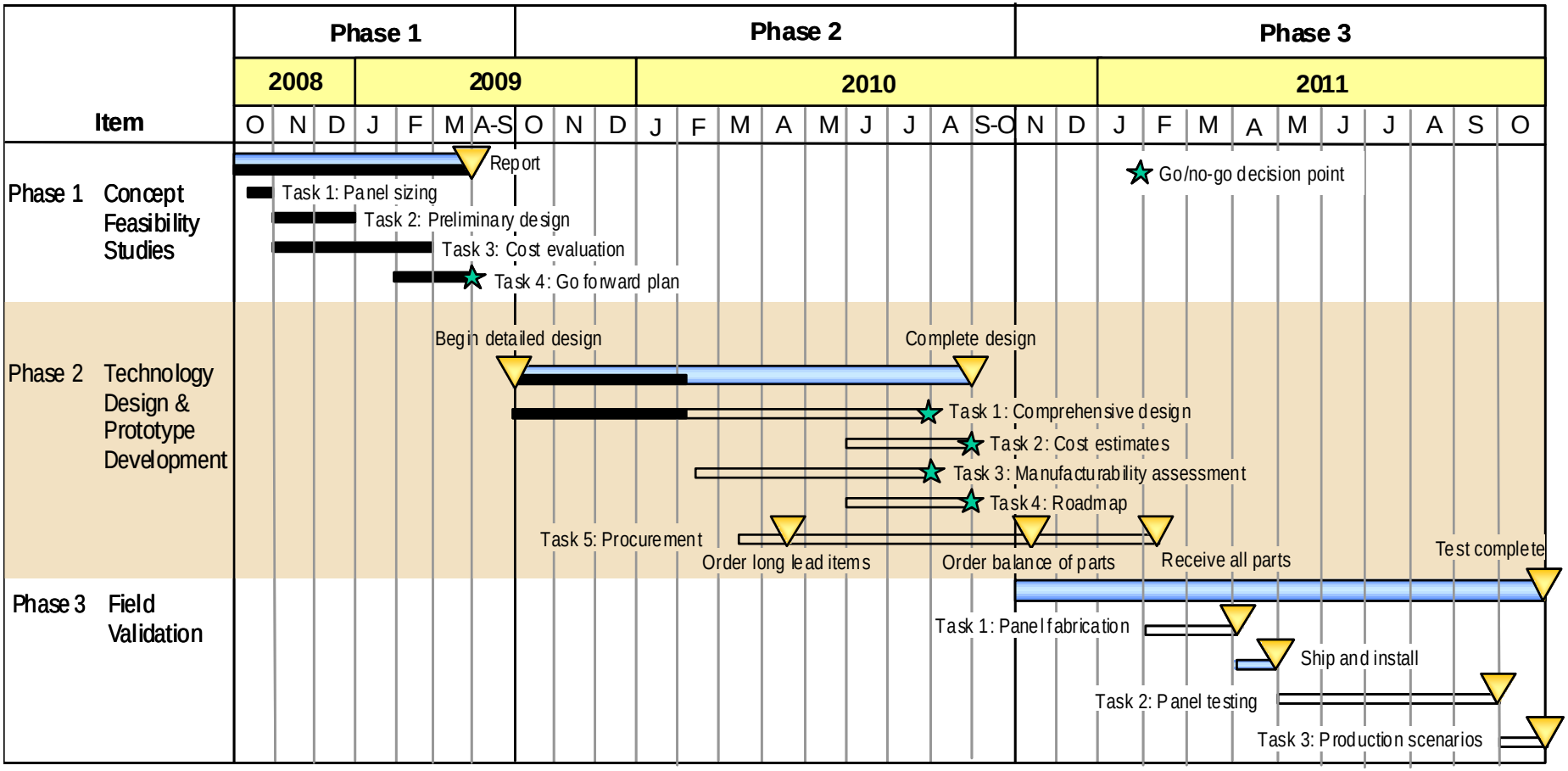


- Design, fabrication and test a sub-scale receiver panel
  - Prototypic of an advanced large receiver system
- Confirm panel size and perform preliminary design
  - Size panel to limitations of National Thermal Solar Test Facility (NSTTF) at SNL
  - ~10 ft. of active length, 25 ft. in overall length, width ~45 inches.
- Comprehensive panel design
  - Structural, thermal-fluid analyses and materials engineering
  - Detailed component specifications
  - Manufacturability assessment
- Panel fabrication, production run on repetitive components
- Panel testing at NSTTF, on-sun with molten salt
- Evaluation of future production scenarios and costs

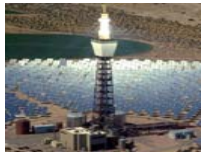
Project Overview



Activities, Planned Milestones & Budget



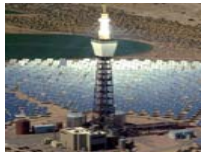
2009 Progress Report



- Completed Phase 1 during the first quarter
  - Panel sizing
  - Preliminary design
  - Cost evaluation
  - Go forward plan
  - Submitted Phase 1 report summarizing progress

- Started Phase 2 in last quarter
  - Revisiting design innovations
  - Finalizing 3D model

Future Activities



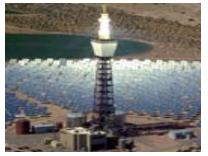
2010 Planned Activities

- Complete Phase 2 work
  - Comprehensive design and cost estimates
  - Manufacturing assessment
  - Long lead procurement
  - Design Review and submit Phase 2 report
- Initiate Phase 3
  - Complete remaining procurement
  - Start fabrication of panel

2011 and Beyond Ideas

- Complete fabrication and ship to NSTTF
- Install and complete testing - design validated
- Design and fabricate full scale (~500 MWt) receiver systems incorporating lessons learned from this project

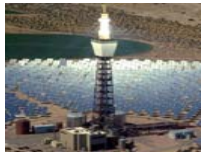
Link Project to Program Plans & Goals



- Forecast achievement of utility CSP cost targets
  - Selecting new materials to lower fixed costs
  - Lowering the complexity of the design to achieve ease of manufacturing and cost reduction
  - Utilizing faster and less expensive fabrication techniques
  - Implementing design decisions and creating on the tower repair techniques that will lower the variable costs of plant operation

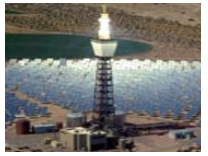
- Project addresses barriers:
  - Large-size
  - Capital cost
  - Reliability
  - Performance
  - Technology risk

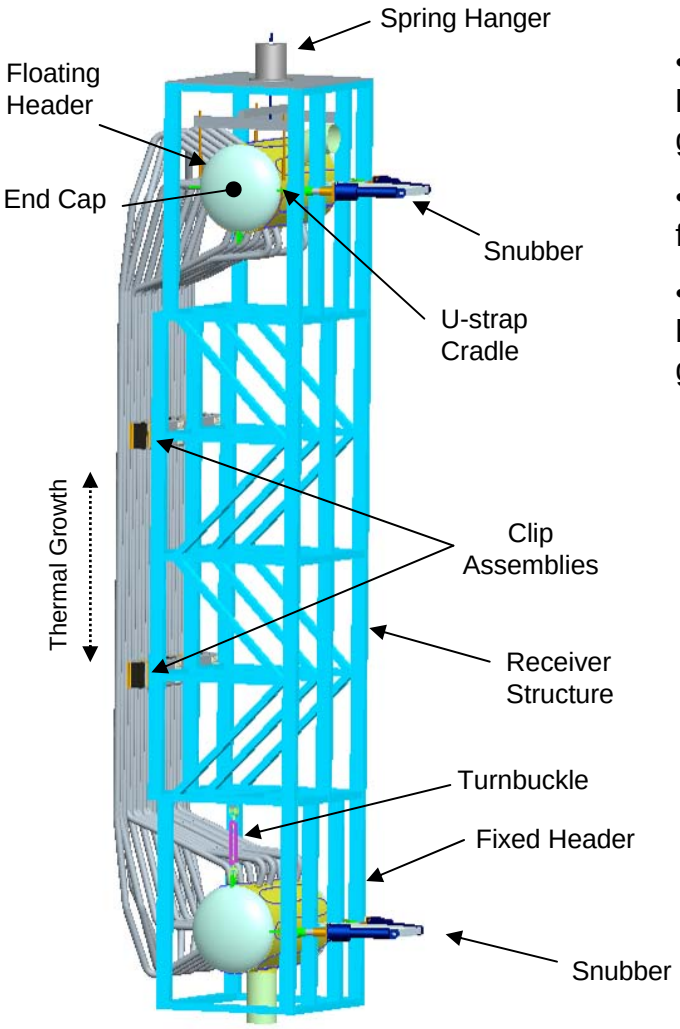
Receiver Design



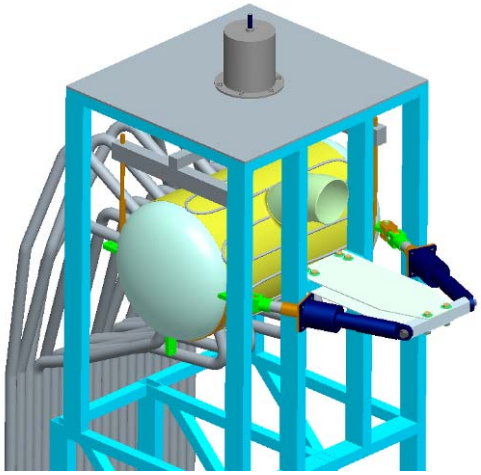
- Current status
  - Basic Design is complete
    - Need to finish with design details
    - Start drawing creation
  - Working on test plan and interface control drawing
  - Working with vendors for part procurement

Header Assembly

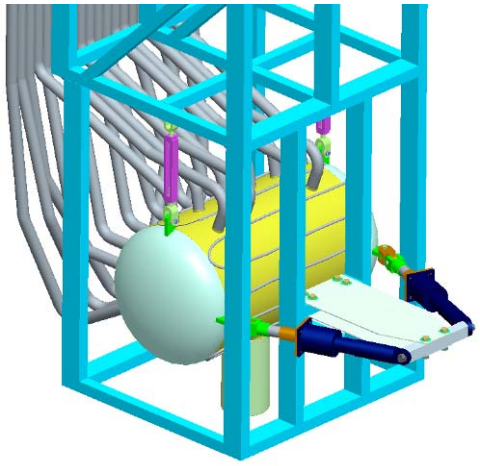




- Snubbers maintain header location while allowing thermal growth
- Spring hanger helps support the floating header and tubes
- Turnbuckle supports the fixed header and allows local thermal growth



Floating Header



Fixed Header

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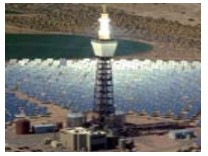
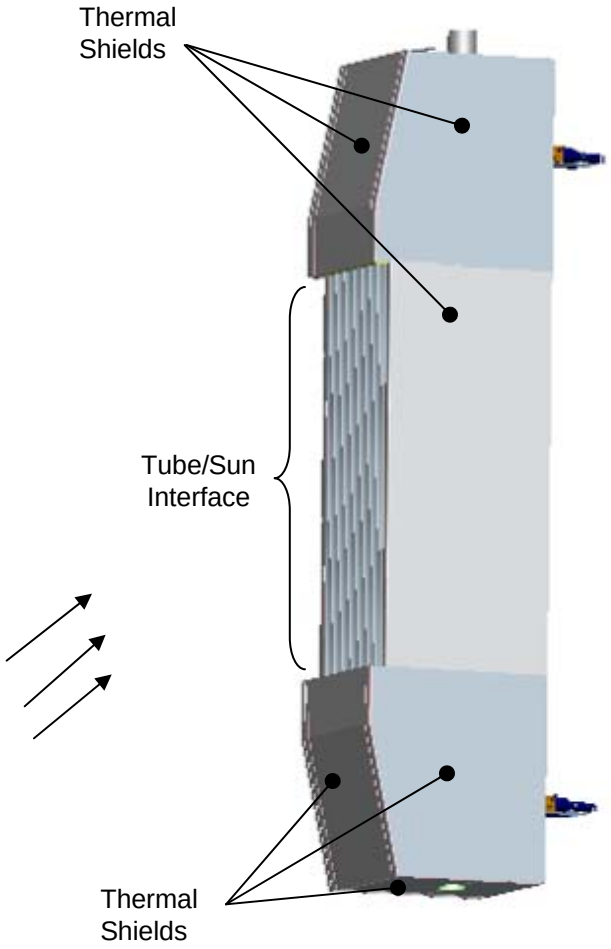
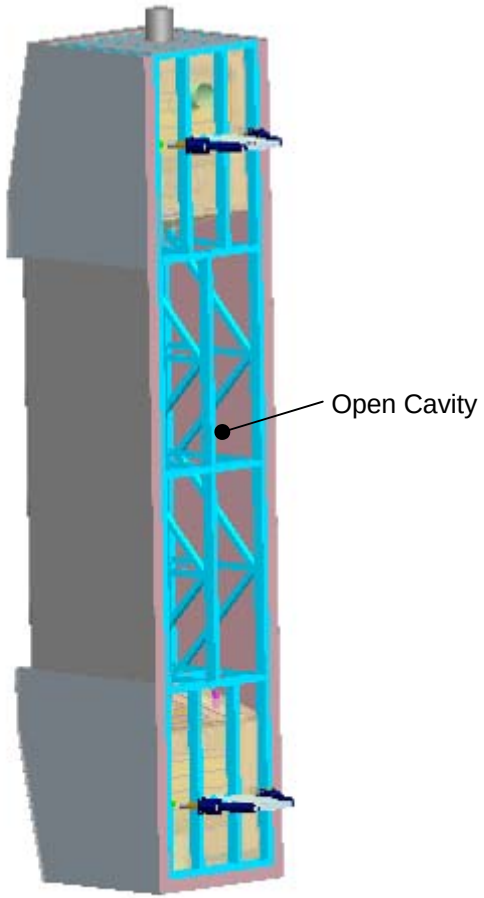
Thermal Shields

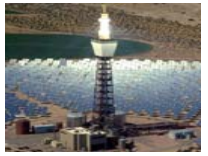




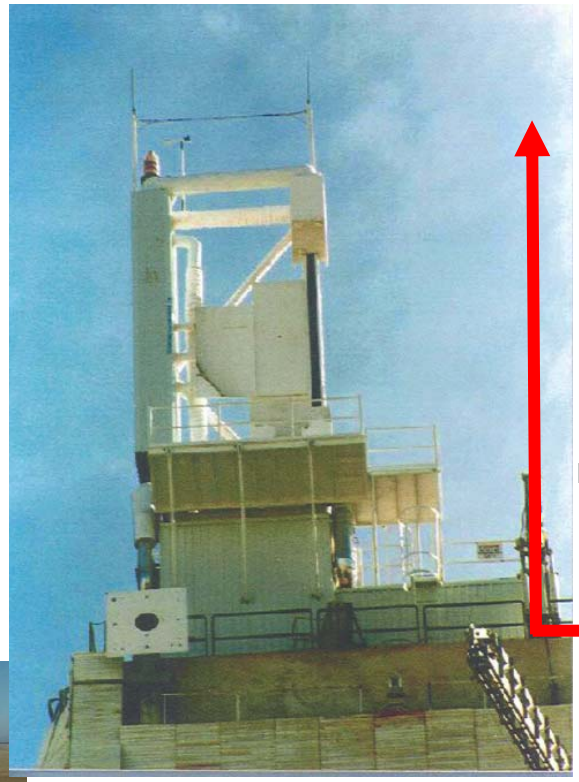
- Thermal shields protect adjacent structure from solar spillage



Test Plan Overview



- New receiver molten salt loop to be designed and fabricated at Sandia
- Test operating conditions for receiver:
  - Heat flux of 1,050 SUNS (1,050 kW/m^2)
  - Receiver will operate with:
    - Molten Salt Temperatures - 550° F to 1,050° F



Facility to be new from this level up

Receiver to be mounted on top of the tower

Sandia Test Facility

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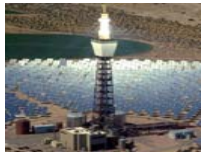
Conclusion



- Design is progressing well
  - Finishing details of the design
  - Starting process of creating drawings
  - Creating interface control drawing
- Engaging Sandia in communication so that integration of the receiver and test facility go smoothly