NCSX Manufacturing Studies: *A Summary of the August 22 Manufacturing Information Meeting at PPPL*

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August 29 NCSX Project Meeting

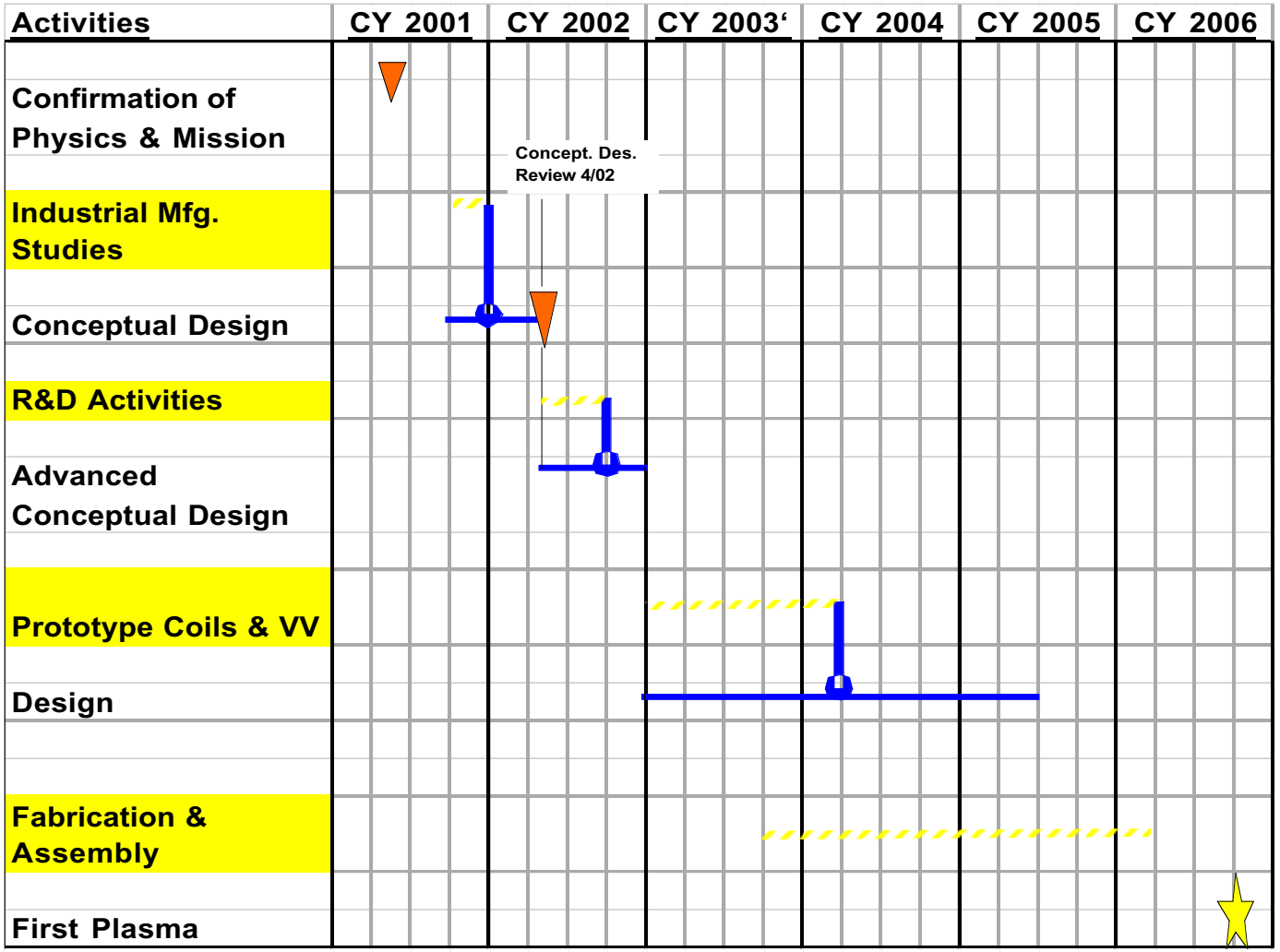
Goals of the Aug. 22 Mfg. Information Meeting:

1. To present and get feedback from you on Engineering & Procurement plans for the Vacuum Vessel and Modular Coils of NCSX and the modular coils of QPS.
2. To solicit expressions of interest from you for possible participation in manufacturing studies, R&D, and prototypes.
3. To encourage manufacturers that may only have partial capability to team with others with complementary capability.

Attendees

ANSALDO Superconduttori S.p.A.
sterby Giuteri AB
Metaltek International
New England Electric Wire
Advanced Energy Systems, Inc.
Oak Ridge Center for Manufacturing Technology at Y-12
University of Wisconsin˚
Fusion & Accelerator Department University of Wisconsin˚
U. S. Bronze Foundry & Machine
Mitsubishi Electric Corporation
Mitsubishi Heavy Industries, Ltd.,
Everson Electric Corporation
Hitachi Ltd.
Dynamic Materials Corp
Major Tool & Machine, Inc.
Metaltek International/ Carondelet Division
American Exchanger Services, Inc.
Penn Iron Works
J.P. Pattern Inc.
Atlantic Technical Components, Inc.
Kobe Shipyard and Machinery Works
The Boeing Company

Plan Elements and Schedule



Industrial Manufacturing Studies

- **We request those interested in participating in Manufacturing Studies to notify us by 8 September .**
  - **Requests for Proposals will be issued to respondents in mid-September.**
  - **We anticipate awarding several contracts in the $20-30K range in late November.**
    - ***All information contained in the reports must be able to be freely disseminated to project participants, including industrial participants.***
  - **These reports should, at a minimum, include:**
    - **Background information on your company or team that would help us become acquainted with your capabilities and relevant experience.**
    - **Your vision of the manufacturing methodology for the vessel and/or coils. Most important are the implications of this methodology on our designs and specifications.**
    - **Your thoughts on how the specification(s) can be improved.**
    - **Your thoughts on R&D and prototyping needs.**
    - **A budgetary cost estimate for the production units.**
  - **Manufacturing Study Reports of the modular coils and/or vacuum vessel are to be submitted by January 31, 2002.**
    - **This schedule will allow us to factor this information into our Conceptual Design which is scheduled for review in April, 2002.**

Prototypes and R&D

Requests for Proposals for Research and Development (R&D) and Prototypes will be made in mid- CY 02 for:

1. **R&D for critical areas and prototype fabrication for a vacuum vessel sector.**
   - Sector definition dependent on process and proposed segmentation.
   - Purpose is to demonstrate the viability of the proposed manufacturing process.
     - If the demonstration is highly successful, this part could become the first segment of the manufactured vessel.

2. **R&D for critical areas and a prototype modular coil (probably the most highly shaped one).**
   - To be built to same quality standards as production coils.
   - Purpose is to demonstrate the viability of the proposed manufacturing process.
     - If highly successful, this coil could qualify as a spare coil or it may even become the first production coil.

Manufacture

- **Coil and vessel manufacturing for NCSX is scheduled to begin late in 2003, and will have a duration of approximately 2 yrs.**
  - **Requests for Proposals for Manufacture will be made in mid- CY 2003.**
  - **We expect there to be one supplier for the coils and one supplier for the vacuum vessel.**
    - ***It is probable that the successful supplier will be selected from the prototype manufacturers*.**

Supplier Participation

- **Manufacturing Studies:**
  - Several suppliers will be selected to participate in the vacuum vessel and the coil studies.
  - Suppliers who do not participate will still be eligible to bid on the R&D and Prototype contract.
  - These studies are to be done on a fixed price basis.

R&D and Prototype Phase:

- 2 suppliers anticipated for the vacuum vessel;
- 2 suppliers anticipated for the modular coils.
- Contracts are likely to be cost reimbursement type.

Manufacture

- Suppliers for Manufacture will be selected from the R&D and Prototype suppliers.
- A fixed price contract for the vacuum vessel is planned.
- A fixed price contract for the modular coils is planned.

This phased strategy is designed to build the information and confidence required to minimize risk in the manufacturing phase.

Meeting Feedback on the Vacuum Vessel

- VV wall thickness tolerance suggested: +/- 1/16
- HSX vessel was within 1/8 -check
- Suggest coining in datum points.
- Use Blanchard ground plate to attain surface finish.
- Minimize welds for good vacuum properties, low magnetic permeability, and dimensional control.
- Need to develop a way of attaching end covers for leak testing.
- Pro E file transfer method OK —
  — IGES or STEP files
- Tolerance band shown for vacuum vessel is OK.
- Consider thinner corrugated walls
- Explosion form-thickness, shape, size not a problem, but tooling is formidable.
- Suggest making and testing a small cast vacuum chamber to determine acceptability of castings for vacuum applications.
- Inco 620 casting should be considered

Meeting Feedback on the Modular Coils

- _ for casting tolerance is too tight .
  - After heat treatment, the part may be 1.5-2 out of tolerance.
  - Hand work to reduce distortion is required before machining.
  - Considerable machining is needed.
- Consider making castings both with and, if results are unsatisfactory, without the support shells.
- Machining tolerance for coil areas of +/-0.005 is readily achieved.
  - +/-.010 is cheaper. Keep in mind this is tough for a big part like this. W7X was +/- 1 mm on 5 axis CNC.
- Permeability of castings of 1.01 was achieved on W7X.
- Pro E file transfer of geometry is OK.
- Will get epoxy in between strands with VPI.
  - Vacuum bagging will not be easy.
  - May want to consider an autoclave.

Summary

- ***I believe the meeting goals were realized:***
  - **Good feedback on manufacturing issues; just a little on project plans, but the feedback we got seemed to indicate that our plans are reasonable.**
  - **We are now awaiting responses on Sept. 8 from those interested in manufacturing studies. We expect a good response.**
  - **Many of the attendees were discussing teaming arrangements.**
- ***We learned a lot.***
  - **We will have to work hard with manufacturers to achieve tolerances we can live with at a price we can afford.**
    - **Will have to be careful not to overspecify so we can keep costs in line.**
    - ***Tight tolerances are achievable, but at high cost. We need to really determine how tight our tolerances must be!***
  - **Cable samples from New England Cable were very flexible; winding portion of the coil manufacture is probably going to be fairly easy.**
  - **Difficulty of vessel manufacture may equal or exceed the coils**
    - **None of the attendees had experience with cast vacuum vessels.**
    - **Press forming will require multiple adjustments to dies; may be expensive and difficult.**
    - **Very few explosive fabricators**