Key Characteristics

• Goals of this class
  – Introduce Key Characteristics (KCs)
  – Define the notions of KC delivery and KC delivery chain
  – Understand the relationship between KC delivery chains and part-to-part location
  – Appreciate how many KCs an assembly can have, including the concept of KC conflict
  – See some examples
Key Characteristics (KCs)

• Key characteristics are product requirements that demand attention because
  – they are critical for performance, safety, or regulations
  – AND
  – they are at risk of not being achieved due to process variations

• Usually, KCs are geometric relationships between features on non-adjacent parts

• Two basic issues for KCs are
  – priorities
  – flowdown
“Chain of Delivery” of Quality

No single part “delivers” the KC.

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Source:
Chains Deliver KCs

• KCs are delivered by chains that must operate repeatably
• Chains are made up of:
  µ physical elements: parts, sub-assemblies, tools, and fixtures
  µ the associated organizations (supply chain)
  µ the capability of the processes (technology)
• Each KC is delivered when its chain is complete
KC Priorities

- Everything is important to someone
- KCs should be confined to things that are not only important but are at some risk of not being achieved
- Usually, manufacturing or assembly variation are considered to be the main threat
- So there is a direct link between KCs and assembly tolerances
- If there is no systematic process for identifying KCs, and if priorities are not assigned, then KCs tend to proliferate
When Can Key Characteristics Be Used?

• During concept design, to capture customer req’mts

• During system engineering, to flow down req’mts to lower levels of the design process

• During detail design, to deliver req’mts via tolerances and process planning

• During supplier selection and preparation of specs, to define deliverables

• During program management, to track and assure achievement of requirements
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Source:
Stapler KCs

KC: Hammer aligns with last staple

KC: Last staple aligns with crimper

Staple

Hammer

Crimper
Each KC is Delivered by a Chain
Key Characteristics and the Liaison Diagram

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Source:
Only Some Liaisons Matter in KC Delivery

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Source:
The Delivery Path for Each Stapler KC

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Optical Disk Drive KCs

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KC Flowdown

• Product KCs can be defined for customer requirements and then decomposed into lower level Assembly and Manufacturing KCs

• Achievement of the PKCs requires achievement of the AKCs and MKCs

• Full implementation requires that each AKC and MKC meet a specific tolerance or Cpk

• Suppliers’ capability may limit AKCs and MKCs, requiring flow-up and negotiation
Some “Statistics”

- A person at GM said
  - 60% of body sheet metal tolerances can be met
  - 40% must be altered to meet shop capabilities
- A patent from Boeing on tolerancing says that typically 8 parts are involved in a tolerance chain (probably similar to the length of a KC chain for us)
- A survey of 600 consumer products by Ulrich and Ellison reveals that about 6 parts are involved in delivering functions that differentiate the product in the marketplace
- You don’t get real numbers like this every day
How Parts Locate Each Other to Deliver Quality at the Customer Level

KC=Key Characteristic
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Source:
Door Assembly

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Source:
How Doors are Built

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Source:
Car Door Design KCs

Side View

up-down

<table>
<thead>
<tr>
<th>A Pillar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinges</td>
</tr>
<tr>
<td>Outer Fender</td>
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fore-aft

B Pillar

Latch bar

Top View

Weather seal KC depends on placement of the inner panel

Appearance KC depends on placement of the outer panel

in-out

Appearance KC
= uniformity of this gap

doctor tolerances and fit

KCs_04.ppt 9/13/2004 © Daniel E Whitney
Two Door Methods - There Are Many

Assembly Step 1a

Assembly Step 1b

Assembly Step 2a

Assembly Step 2b
KC Conflict in Door Assembly

Impossible to assemble this way!

Align door inner to seal, then attach inner to frame

Align door outer to frame gaps, then attach outer to inner

Difficult to achieve both KCs this way!

Attach door outer to door inner, aligning parts

Mount door (inner+outer) to frame and align seals, possibly misaligning gaps

Mount door (inner+outer) to frame and align gaps, possibly misaligning seals

Not enough independent DOF available

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Ford Hinge Mounting

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Ford Hinge Mounting Fixture

Photo removed due to copyright restrictions. (Detail of car door front and rear locator pins and holders for hinges.)
Door on Hinge-Mounting Fixture

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Ford Door Mounting to Car

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Source:
Mustang Body in White

Photo removed due to copyright restrictions. (Detail of car door front and rear locators.)
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Source:
An Interesting Wrinkle

• Doors are usually installed on a car before painting and removed for trim installation
  – you can grab a door rigidly (accurately) when there is no paint to scratch
  – it is easier to install stuff on/in the door and in the car if the doors are separate

• The challenge is to get them back on in the right place without the benefit of assembly tooling

• It is done cleverly with the hinges
  – install door+hinges to car, remove door from hinges
  – remove a temporary hinge pin, reinstall a final one
  – check which bolts have paint to see how it was done
GM Hinge Mounting

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Source:
GM Take-apart Car Door Hinges

Photo removed due to copyright restrictions. (Detail of car door hinges and locator cone.)
GM Door Mounting to Car

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Source:
Ford Locator Drawing

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Conclusions

• KCs are the link between functional customer needs and physical realizations at the assembly level
• KCs are delivered by chains of parts
• KCs can be delivered in more than one way
• Design of KC delivery requires definition of location schemes by which parts are related to each other in 6 dof
• Assemblies typically have many KCs, and they can conflict